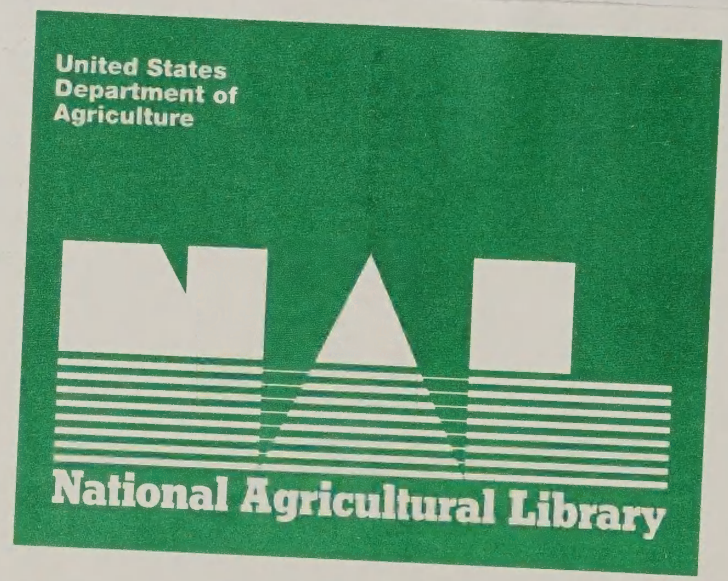
A National Program of Research for

FRUIT

Prepared by

A JOINT TASK FORCE OF THE
U. S. DEPARTMENT OF AGRICULTURE
AND THE STATE UNIVERSITIES
AND LAND GRANT COLLEGES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FOREWORD

The United States Department of Agriculture and State Agricultural Experiment Stations are continuing comprehensive planning of research. This report is a part of this joint research planning and was prepared under recommendation 2 (page 204, paragraph 3) of the National Program of Research for Agriculture.

The task force which developed the report was requested to express their collective judgment as individual scientists and research administrators in regard to the research questions that need to be answered, the evaluation of present research efforts, and changes in research programs to meet present and future needs. The task force was asked to use the National Program of Research for Agriculture as a basis for their recommendation. However, in recognition of changing research needs it was anticipated that the task force recommendations might deviate from the specific plans of the National Program. These deviations are identified in the report along with appropriate reasons for change.

The report represents a valuable contribution to research plans for agriculture. It will be utilized by the Department and the State Agricultural Experiment Stations in developing their research programs. It should not be regarded as a request for the appropriation of funds or as a proposed rate at which funds will be requested to implement the research program.

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This report has been prepared in limited numbers. Persons having a special interest in the development of public research and related programs may request copies from the Research Program Development and Evaluation Staff, Room 318-E Administration Building, USDA, Washington, D.C. 20250.

February 1969

PREFACE

Authority: The Joint Task Force on Fruit Research was appointed by the Director of Science and Education and the Chairman, Experiment Station Committee on Organization and Policy, in a memorandum dated April 30, 1968.

Membership:

Cochairmen

L. C. Cochran, Chief
Fruit and Nut Crops Research Branch
Crops Research Division
Agricultural Research Service
U.S. Department of Agriculture
Beltsville, Maryland 20705

S. H. Wittwer, Director
Agricultural Experiment Station
Michigan State University
East Lansing, Michigan 48823

Members

SAES

L. W. Boulanger, Professor
Department of Entomology
University of Maine
Orono, Maine 04473

H. H. Bowen, Assistant Professor
Soil and Crop Sciences
Texas A&M University
College Station, Texas 77843

R. M. Gilmer, Acting Head
Department of Plant Pathology
New York State Agricultural Experiment Station
Geneva, New York 14456

Coby Lorenzen, Jr.
Professor, Department of Agricultural Engineering
University of California
Davis, California 95616

Dwight Powell, Professor
Department of Plant Pathology
University of Illinois
Urbana, Illinois 61801

P. F. Pratt, Professor and Chairman
Department of Soils and Plant Nutrition
University of California
Riverside, California 92502

Herman J. Reitz, Horticulturist and Head
University of Florida Citrus Experiment Station
P.O. Box 1088
Lake Alfred, Florida 33850

Heinz Spielmann, Associate Professor
Department of Agricultural Economics
University of Hawaii
Honolulu, Hawaii 96822

USDA

Frank P. Boyle, In Charge of Processing Technology Investigations
Fruit Laboratory
Western Utilization Research and Development Division, Agricultural Research Service
800 Buchanan Street
Albany, California 94710

R. E. Hardenburg
Research Horticulturist
Horticultural Crops Research Branch
Market Quality Research Division
Agricultural Research Service
Beltsville, Maryland 20705

J. H. Levin, Leader of Fruit and Vegetable Harvesting
Agricultural Engineering Research Div., Agricultural Research Service
Michigan State University
East Lansing, Michigan 48823

Jules Powell, Assistant Chief
Horticultural & Special Crops Branch
Marketing Economics Division
Economic Research Service
Washington, D.C. 20250

J. K. Samuels, Asst. Administrator
Cooperative Marketing and Farm Supplies Program
Farmer Cooperative Service
Washington, D.C. 20250

E. A. Taylor, Acting Chief
Fruit & Vegetable Insects Branch
Entomology Research Division
Agricultural Research Service
Beltsville, Maryland 20705

M. K. Veldhuis, Chief
U.S. Fruit & Vegetable Products Laboratory
Southern Utilization Research and Development Division, Agricultural Research Service
Winter Haven, Florida 33880

Advisors

Edwin Crosby, Director
Agriculture Division
National Canners Association
1133 20th Street, N.W.
Washington, D.C. 20036

Fred Westberg
Washington State Fruit Commission
622 West Yakima Avenue
Yakima, Washington 98902

Staff Secretary

W. C. Dachtler
Research Program Development and Evaluation Staff
U.S. Department of Agriculture
Room 331-E, Administration Building
Washington, D.C. 20250

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RESEARCH AREAS

The Joint Task Force for Fruit Research was instructed to indicate which areas of research need emphasis, and to ascertain the most efficient procedures for organizing and carrying out the specific research. The following Research Problem Areas were assigned to this Task Force:

RPA	Title
204	Control of Insect Pests of Fruit and Vegetable Crops
205	Control of Diseases of Fruit and Vegetable Crops
206	Control of Weeds and Other Hazards to Fruit and Vegetable Crops
304	Improvement of Biological Efficiency of Fruit and Vegetable Crops
305	Mechanization of Fruit and Vegetable Crop Production
306	Systems Analysis in Production of Fruits and Vegetables
402	Production of Fruit and Vegetable Crops with Improved Consumer Acceptability
403	New and Improved Fruit and Vegetable Products
404	Quality Maintenance in Marketing Fruits and Vegetables
501	Improvement of Grades and Standards
503	Physical and Economic Efficiency in Marketing Fruits and Vegetables

The Task Force also considered the following Research Problem Areas, involving research of major significance to the fruit industry:

RPA	Title
102	Soil Structure; and Soil, Plant, Water, Nutrient Relationships
105	Conservation and Efficient Use of Water for Agriculture
106	Efficient Drainage and Irrigation Systems and Facilities
314	Bees and Other Pollinating Insects
506	Supply, Demand, and Price Analysis
507	Competitive Interrelationships in Agriculture
508	Development of Domestic Markets for Farm Products
510	Farmer Bargaining Power
511	Improvement of Agricultural Statistics
601	Expansion of Foreign Markets for U.S. Farm Products
702	Protect Food Supplies from Harmful Microorganisms and Naturally Occurring Toxins
901	Alleviate Soil, Water, and Air Pollution

INTRODUCTION

The production, harvesting, handling, and marketing of 20-25 million tons of fruit with a farm value in excess of $2 billion is an important component of American agriculture. History reveals, that except for a few crops, there has been little, if any, over-production of fruit in the United States. Shortages both for fresh market and processing have been common. Research is needed not only for increasing the efficiency of production and marketing but, at the same time, to reduce losses in harvest, handling and storage.

A large portion of the vitamins and minerals of the American diet originate from fruit. In addition to basic food value, fruit contributes many pleasing variations to our diet, and provides exquisite flavors not available from other sources. As standards of living continue to rise, fruit will play an increasingly important role.

Fruit crops (tree fruits, small fruits, nuts) constitute the most stable component of our agricultural economy. Long-time investments by growers in land and commitments of resources are required before any monetary return is realized.

Changing production practices will increasingly involve chemical and prescription-type weed control, use of systemic insecticides and fungicides, biological pest control, insect sterilization techniques, preservation and propagation of beneficial insects for pollination, disease resistant varieties, eradication of soil-borne pathogens, low and ultra low volume spraying. There is an increasing array of bioregulants for the control of flowering, fruit thinning and setting, tree size and shape, fruit maturity, abscission and storage quality.

New genetic combinations in variety development must be evaluated in relation to rootstocks, interstocks, and bud sports. In the use of fertilizer, the effects of storage reserves, biennial bearing, an increasing frequency of disorders associated with micronutrient deficiencies, soil moisture variables, irrigation practices and the potential of application by foliar treatment must be considered. Protection from low temperature injury and other environmental hazards commands high priority, along with programs to reduce deer, rodent, and bird damage.

The demands of successful fruit growing are specific as to soil, temperature, and moisture. This has concentrated the production areas. Encroachment by urbanization upon good orchard sites has reduced potential grower migration to new land. Old sites must be used for new plantings. Unusual problems and research needs have followed. Unlike efforts for other agricultural commodities, little long-term production research is

being conducted by industry. Cost accounting studies, likewise, vital to the fruit industry, have been grossly neglected.

A dramatic transition is now occurring in the production, harvest, handling, storage, marketing, and utilization of fruit. Labor availability and efficiency have become the most limiting factors in all fruit production. Harvest mechanization must be rapidly advanced for all fruits utilized in processing, and will eventually be required for those marketed fresh. The impact of harvest mechanization is of such magnitude that all fruit crops should now be planted, using appropriate varieties, coupled with modification in culture, plant densities, and training to accommodate machine harvest. All fruit research should be conceived and designed so that mechanization is a built-in component.

Mechanization of harvest is only the first stage in the changing pattern of future research needs. Hydro-handling, improved refrigeration and cooling, controlled atmosphere storage and transport, preservative treatments and new product development accompanied by an increasingly greater percentage being used in processing should guide future research planning.

Harvest mechanization and its many resultant implications is now a major and immediate concern for the total fruit industry. There is some confidence, however, that solutions will come and relatively soon. A more serious long-time problem is the widely fluctuating yields and resultant fluctuating supplies, demand, and prices. The control of temperature extremes, or moderation of their effects, along with other methods of regulating flowering and fruiting, constitute a great research challenge in fruit crops.

That which follows is an appraisal and projection of research needs according to problem areas. The situations are described, the objectives given, the research approach outlined, anticipated benefits listed, and the future manpower needs itemized. An increase in scientist man-years (SMY's) is recognized as the index of greater research investment, and constitutes the estimated research base of this report for the future. It is equally important that adequate supporting personnel and increasingly sophisticated equipment needed by the good scientists we already have, be provided.

An overlap with many other task force reports is inevitable and has been recognized. Fruit commodities are diverse and the research needs for varietal development, culture, harvesting, handling, storage, transportation, grading, utilization, packaging and merchandizing are equally divergent. Commodities of concern to this task force include decidious, citrus, tropical, subtropical, small fruits and berries, and tree nuts.

A further spin-off of the inevitability of harvest mechanization, now modifying all needs, is that research on fruit crops, now and in the future, will demand cooperation and interdisciplinary efforts of biologists, food scientists, engineers, physical scientists and economists.

RESEARCH PROJECTIONS BY FRUIT TASK FORCE

Research Problem Area	Scientist Man-Years			
	1966 (Base)	1972	1977	Percent Increase
204 Insect Control	97	162	190	96
205 Disease Control	130	150	187	44
206 Weeds and other Hazards	17	30	35	103
304 Biological Efficiency	263	309	363	38
305 Mechanization	38	45	50	32
403 New Products	120	158	201	68
404 Quality in Marketing	54	66	83	54
501 Grades and Standards	4	12	18	350
503 Marketing Efficiency	29	33	41	41
Totals or Average	752	965	1168	55

RECOMMENDED RESEARCH BY PROBLEM AREAS

RPA 204 - CONTROL OF INSECT PESTS OF FRUIT AND TREE NUT CROPS

INTRODUCTION: Insects cause an estimated $312 million dollars of direct damage to fruit and tree nuts. They also serve as vectors for diseases which cause about $83 million in losses. An additional $196 million is spent on direct control of insects. 1/

An estimated 5 million acres of fruit and nut crops are treated 1-10 times with insecticides each year. This situation in itself is becoming somewhat untenable in view of a rapidly changing scene in the development and use of insecticides.

The emergence of effective integrated control systems and bioenvironmental methods of suppressing insect and mite populations attacking fruit and tree nuts have indicated promise for future efforts. Implementation of these new concepts could reduce the total cost of insect activity by some $300 million dollars and also greatly reduce the hazard of insecticide residues on fruit and tree nut crops and their introduction into the environment.

RPA 204-A Biological and Integrated Control of Insects and Mites Attacking Fruit and Tree Nut Crops

SITUATION: Without control measures, more than 50 percent of the pome fruit crop in the United States would be lost because of insect damage, principally the codling moth. Losses in stone fruit also would be serious. Although citrus and tree nut crops are not so severely threatened, substantial losses would occur on these as well. Growers apply a number of insecticide sprays throughout the growing season to prevent or minimize insect and mite damage on pome and other fruit and tree nut crops. Insecticides, however, can disturb ecological balances by destroying beneficial insect species; this often permits destructive insects to reach damaging numbers. Many insect pests attacking these crops could be held below the threshold of economic damage by insect parasites and predators, and disease pathogens if insecticides were not used as extensively to control one or more of the major insect pests.

OBJECTIVE: Reduce direct and indirect insect damage to fruit and tree nut crops through the development of multilateral and selective control methods for the major insect pests, utilizing natural enemies, attractants, repellants, and selective insecticide or cultural techniques.

1/ USDA ARS Handbook #291

RESEARCH APPROACHES:

A. Identify insect parasites and predators of insect pests of fruit and tree nut, determine the extent of control exerted by these biological agents and the environmental and cultural conditions which favor their effectiveness, develop methods of mass rearing insect parasites and predators, and determine effect of supplementary or sustained releases of parasites and predators on insect pest populations.

B. Identify insect pathogens which are effective in controlling fruit and tree nut pests; determine the biological and environmental conditions which influence infection; develop methods for mass culture and practical application of pathogens under field conditions.

C. Isolate, identify, and synthesize insect sex and feeding attractants and develop methods of utilizing these attractants alone or in combination with electromagnetic traps or chemicals to control or suppress populations of major insect pests of fruit and tree nut crops.

D. Conduct tests with two or more promising independent insect control techniques in integrated control systems that may be used by commercial growers.

POTENTIAL BENEFITS: More effective biological control of insects attacking fruit and tree nut crops would reduce the cost of production, increase quality and yield of marketable fruit and tree nuts, reduce insecticide residues on harvested crops and environmental pollution, and minimize insecticide hazards to honeybees and other pollinating insects.

RECOMMENDED RESEARCH EFFORT:

TF Recommendation
(Scientist Man-Years)

1972	1977
33	43

RPA 204-B Improvement of Chemical Control of Insects Attacking Fruit and Tree Nut Crops

SITUATION: Approximately 5 million acres of fruit and tree nut crops are treated with insecticides each year. The high per-acre value of these crops often requires frequent and heavy applications of insecticides to

insure profitable yields and quality levels acceptable for the fresh market and processing. These chemical control programs often involve the use of broad spectrum insecticides that leave residues on harvested fruit and tree nuts and in the environment. Nonselective insecticides also have had some adverse side effects such as the development of arthropod resistance to chemicals, destruction of honeybees and other pollinating agents, and interference in the role of natural biological agents that normally suppress many plant-feeding insect populations.

OBJECTIVE: To develop safer, effective, and more selective insecticide control methods that will not leave objectionable insecticide residues on the harvested fruit and tree nuts or in the environment, or cause minimum damage to honeybees and beneficial insects.

RESEARCH APPROACHES:

A. Screen new chemicals as they become available to find safer, more effective selective insecticides.

B. Evaluate new insecticide formulations, rate and timing of applications, and various types of application equipment under cultural systems adapted to mechanical harvesting. Develop new cultural practices that will provide more effective control of target insects and prevent drift of insecticides from treated areas.

C. Evaluate adverse side effects of insecticides on honeybees and other pollinating or beneficial insects.

D. Integrate insecticides with other measures such as chemical attractants, light traps, insect parasites, predators, and pathogens to produce economic insect control systems that may delay or prevent the development of insect resistance to insecticides and reduce hazards from the use of insecticides. Coordinate fate of insecticides in soil with RPA 901.

POTENTIAL BENEFITS: More effective chemical control with selective, less persistent insecticides that will not leave objectionable residues on fruit and tree nut crops; alleviate the development of insect resistance to insecticides; lessen damage to honeybees and other beneficial insects, fish, and wildlife.

RECOMMENDED RESEARCH EFFORT:

TF Recommendation (Scientist Man-Years)	
1972	1977
27	32

204-C Biology of Insects Attacking Fruit and Tree Nuts

SITUATION: The discovery of sex attractants in several major insect species that attack fruit and tree nut crops has provided new tools for obtaining more detailed knowledge of the biology and ecology of insect pests. Where new detection techniques have been studied, they have revealed the more susceptible stages of the life cycle, alternate methods of control, and more effective timing of conventional chemical controls. Development of nonchemical or integrated control methods requires studies of insect pest distribution and quantitative and qualitative information about insect population density, particularly at the low cycle of the population.

OBJECTIVE: To obtain basic biological information on insect pest populations attacking fruit and tree nuts, including occurrence, distribution, population densities, and host range to develop new methods of control or timing of conventional chemical control applications.

RESEARCH APPROACHES:

A. As new detection tools become available, develop more accurate methods of measuring insect population densities, distribution, and seasonal abundance of major insect pests of fruit and tree nuts.

B. Determine in more detail the seasonal life history, including host plant sequence, migration, mating habits, reproductive potential, and the effect of biological agents on the major insect pests of fruit and tree nuts.

C. Determine the effect of cultural practices, presence of noncommercial fruit and tree nuts, and alternate wild hosts on the abundance of the insect pest species.

POTENTIAL BENEFITS: Reduce the cost of fruit and nut production and the amount of insecticides used. Minimize associated problems of insecticide residues on fruit and tree nut crops and reduce the hazard to honeybees and environment pollution.

RECOMMENDED RESEARCH EFFORT:

TF Recommendation
(Scientist Man-Years)

1972	1977
37	43

204-D Bioenvironmental Techniques for Suppression of Insect and Mite Populations Attacking Fruit and Tree Nuts

SITUATION: Although chemical control has provided a means of reducing insect damage and permitted high yields of quality fruit and tree nuts, an estimated loss of $312 million still occurs despite expenditures of nearly $200 million for such control measures. One of the factors responsible for this high cost of control is the large number of applications of present conventional insecticides required to control established infestations of insects and mites, particularly on deciduous tree fruits and nuts. Recent developments in new insect control techniques directed against the low cycle of insect populations, such as release of sterile insects and male annihilation, have shown that insect control can be achieved by creating an environment unsuitable for the survival or increase of the insect species. One of these highly selective methods, sterile insect release, is now being investigated for the codling moth and shows great promise. This, and other new methods of reducing or suppressing the total insect pest population, need to be investigated for many of the key insect pests attacking fruit and tree nuts.

OBJECTIVE: Suppression of insect and mite populations attacking fruit and tree nuts to levels below economic damage thresholds by release of sterile insects, use of insect attractants, and development of plant resistance to insects and mites.

RESEARCH APPROACHES:

A. Conduct tests to determine if major, key insect species that attack fruit and tree nuts can be sterilized by gamma irradiation or chemicals; develop methods of mass rearing each such insect species and evaluate the effect of sustained sterile insect releases on natural insect populations.

B. Conduct area-wide tests with sex or feeding attractants for each major species of insect attacking fruit and tree nuts to determine if males or both sexes can be eliminated from the environment.

C. Conduct ecological studies on the seasonal abundance of each major species of insect attacking fruit and tree nuts to discover the low cycle of the insect populations; study populations on noncommercial plantings or alternate host plants and the effect of removal of these noncommercial plantings and alternate host plants on the natural insect population.

D. Collect and evaluate fruit and tree nut germ plasm for insect and mite resistance; incorporate insect and mite resistance

into commercial variaties. Coordinate with RPA-304.

E. Combine promising techniques of insect population suppression into area-wide integrated systems for total population suppression or eradication of key insect species that attack fruit and tree nuts.

POTENTIAL BENEFITS: Suppression of insect and mite populations which attack fruit and tree nut crops below the threshold level of economic damage with bioenvironmental techniques could greatly reduce losses due to insects and mites, reduce the cost of production and increase quality while avoiding or reducing insecticide hazards to honeybees and other beneficial insects, fish and wildlife, and reduce objectionable insecticide residues on harvested crops and in the environment.

RECOMMENDED RESEARCH EFFORT:

TF Recommendation (Scientist Man-Years)	
1972	1977
65	72

RPA 205 - CONTROL OF DISEASES OF FRUIT AND NUT CROPS

INTRODUCTION: Fruit and nut production involves a large, long-term financial investment in a perennial crop. A major factor in efficient production is adequate control of diseases. Ineffective disease control may result in the loss of an orchard or vineyard. Because of the perennial nature of fruit crops, some of the common methods of disease control -- crop rotation, change in varieties -- are not readily applicable.

Fungicides are applied to fruit and nut crops each year to control the many fungus and bacterial diseases affecting them. An Eastern apple grower commonly sprays his orchard 14 or more times per season and the cost of disease control may equal 20 percent of his total production cost. Although considerable progress has been made in increasing effectiveness of fungicides through introduction of new materials and use of low gallonage air blast applicators, even further progress is needed to lower costs and increase efficiency of protection.

Adequate control measures for several important fruit diseases are still lacking. Valsa canker of peach and prune and fire blight of apple and pear are representative of this group. Valsa canker commonly curtails the useful life of peach and prune orchards by at least a third, and fire blight of apple and pear is still a limiting factor in the production of these fruits in many areas of the Northeastern and Midwestern United States. Control with fungicides or antibiotics is often unsatisfactory. Potentially the most practicable method of controlling these and other diseases is through the development of resistant or immune varieties.

Virus diseases are of serious economic consequence in fruit production. Epidemics of peach yellows and x-disease have destroyed thousands of acres of peach and cherry orchards. Pierce's disease (fanleaf) of grape destroyed 30,000 acres of vineyards in southern California within a single decade, and this virus effectively prevents successful grape culture in many areas of the Southern United States. Pear decline virus killed over 25 million pear trees on the West Coast in the decade 1955-65. Effective control of these diseases is possible only after the means of virus transmission are determined.

An increasingly serious problem in fruit production is the steadily decreasing suitability of large acreages as orchard or vineyard sites. In some cases, soils become infected with certain soil-borne viruses (grape fanleaf, raspberry ring spot), which may infect new plantings. In other instances, particularly in sites that have been previously planted to orchards, new orchard plantings are unthrifty and grow poorly. The exact causes of the orchard replant problem are not clearly understood, although unthrifty tree growth is commonly associated with a complex of nematodes

and soil fungi. Further research into the causes of replant difficulties and means of alleviating them is urgently needed.

Fruit and nut production is currently in the early stages of a pronounced shift in cultural practices aimed at increasing production efficiency. Closer spacing, size control of trees, mechanization of pruning and harvesting, the use of new varieties and rootstocks are major changes already under way. These changes in cultural practices and the advent of mechanized harvest by shaking and other techniques will unquestionably result in the appearance of new diseases, changes in the economic importance of present diseases, and changes in methods of disease control. These problems can be solved only through increased support of research on diseases and disease control methods.

RPA 205-A Control of Plant Diseases by Genetics and Breeding

SITUATION: The use of varieties genetically resistant to plant diseases is a major means of disease control in forage crops, small grains, and vegetables. Breeding for disease resistance in fruits has received comparatively little attention because of the perennial nature of fruit crops and the long periods of time required to evaluate progeny of a breeding program.

Genes or gene complexes conferring resistance for a number of fruit diseases exist and can be incorporated into horticulturally acceptable fruit varieties. Considerable progress has recently been made in developing pear varieties resistant to fire blight and apple varieties resistant or immune to apple scab and fire blight. Resistance to bacterial canker and Valsa canker (peach, cherry), powdery mildews (grape, apple, raspberry, peach), cedar-apple rust (apple), collar rot (apple, pear) and several other economic fruit diseases is known.

OBJECTIVE: To identify genes or gene complexes that confer resistance or immunity to specific fruit diseases and to incorporate these by breeding and selection into horticulturally acceptable fruit varieties.

RESEARCH APPROACHES:

A. Screen foreign and domestic fruits and related species for genetically controlled resistance to plant diseases.

B. Develop methods of disease inoculation that permit reliable and rapid evaluation of breeding progeny for resistance.

C. Incorporate genes conferring disease resistance or immunity into horticulturally acceptable varieties of fruits, in coordination with RPA 304-A and RPA 305.

POTENTIAL BENEFITS: Resistance or immunity to disease is the most economically efficient method of disease control. Successful use would greatly reduce the number of pesticide applications or eliminate them entirely, with concommitant benefits of economy and avoidance of environmental pollution. The use of resistant varieties may also permit fruit culture in areas not now suitable because of disease problems.

RECOMMENDED RESEARCH EFFORT:

TF Recommendation (Scientist Man-Years)	
1972	1977
15	20

RPA 205-B Crop Sequence and Soil Management Practices to Reduce the Incidence of Disease

SITUATION: Diseases resulting from high populations of nematodes and many species of fungi and bacteria are becoming more serious in soil which is continually cropped. Such problems are expected to treble in the next decade. Establishing citrus, deciduous fruit, and nut crop trees on previous orchard sites is more difficult each time. Peach trees often start declining within 10 years on a replanted site. A similar situation exists with other fruit and nut crops. Little is known of the evolution of microflora on land that is continuously cropped. It is possible that certain pathogenic organisms become dominant or other microflora imbalances develop that are detrimental to growth. Not enough is known of the importance of root damage by insects and nematodes and root infections by pathogenic fungi and bacteria. Recent studies have shown that soil fertility may affect the resistance and/or susceptibility of plants to disease. The paucity of acceptable new planting sites due to other land-use programs requires that research be expanded in this area.

OBJECTIVE: Determine the importance of crop sequence and soil management practices to disease prevalence and control in fruit and tree-nut culture.

RESEARCH APPROACHES:

A. Isolate and identify fungi, bacteria, and nematodes from the rhizosphere of fruit and tree-nut plants.

B. Determine microbial population levels in healthy versus declining plants in relation to A.

C. Relate A and B to soil types.

D. Relate A, B, and C to soil management practices, fertility, and crop rotation.

E. Conduct long-term soil treatment studies in relation to information obtained in A, B, C, and D, and coordinate with RPA 304-C.

F. In new plantings compare trees obtained from present day nurseries with trees of known origin which are essentially virus-free. This program applies mostly to tree fruits and should also be coordinated with RPA 304-C.

POTENTIAL BENEFITS: Productive life of fruit and nut plantings can be extended with a resultant reduction in cost of production. High yielding plantings can be maintained at less cost so that more emphasis may be placed on quality-control. A more economical reuse of land should be realized.

RECOMMENDED RESEARCH EFFORT:

TF Recommendation (Scientist Man-Years)	
1972	1977
15	25

RPA 205-C The Role of Insects, Mites, and Nematodes in Transmitting Plant Diseases

SITUATION: Many serious diseases of fruits are transmitted or disseminated by insects, mites, or nematodes. A large number of virus diseases are obligately transmitted by insects or mites and without the vector the virus would be unable to spread. Some of these diseases may cause devastating losses: The leafhopper-borne Pierce's Disease destroyed 10-15,000 acres of vineyards in California in the 1930's, and the psylla-borne pear decline virus killed about 25 million pear trees in 1955-65.

An increasing group of soil-borne viruses (grape fanleaf, peach yellow bud, raspberry ring spot, and others) are being identified as primarily transmitted by soil nematodes. Once established, these diseases may destroy the suitability of agricultural land for fruit production for extended periods.

The dissemination of several fungal and bacterial diseases of fruits by insects or nematodes is usually casual and not obligate. But disease

losses may be very severe, e.g., dissemination of fire blight by insects. Many replant problems in old orchard or vineyard sites probably result from a combination of nematodes and certain soil fungi.

OBJECTIVE: Determine those insects, mites, and nematodes that transmit or disseminate fungal, viral, or bacterial diseases of fruits and reduce the rate of spread of such diseases by control of their vectors.

RESEARCH APPROACHES:

A. Identify specific insects, mites, or nematodes that transmit or disseminate fruit diseases.

B. Study the biology and ecology of such vector species and relate these factors to disease transmission.

C. Develop means of vector control.

POTENTIAL BENEFITS: Increased longevity of fruit plantings; increased yields and quality of virus-free fruits.

RECOMMENDED RESEARCH EFFORT:

TF Recommendation (Scientist Man-Years)	
1972	1977
15	18

RPA 205-D Etiology and Epidemiology of Diseases of Fruits and Nuts

SITUATION: New or previously unrecognized diseases of fruits and nuts are continually being discovered and the causal agents of some described fruit diseases are not yet known. Many of these diseases are of virus etiology. Two such diseases of significant economic importance have been discovered within the past decade (pear decline, apple stem pitting). A third disease (pitted decline of peach) is possibly also virus-induced. A potentially serious canker disease of sour cherry is associated with wounds from mechanical harvesting and is possibly caused by a bacterium. Identification of the causal agent of a disease is an obvious first step in the development of control measures.

Disease epidemiology -- the determination of factors that influence disease incidence and rate of development -- is practically unknown for many serious diseases of fruits and nuts. Knowledge of the life cycle

of the pathogen is generally critical for developing control measures and may result in relatively inexpensive and effective control through removal of alternate hosts or overwintering sources of inoculum.

OBJECTIVE: Determine the etiology and epidemiology of economically important diseases of fruits and nuts and apply this knowledge in developing economic control measures.

RESEARCH APPROACHES:

A. Determine the causal agents of important diseases of fruits.

B. Determine the influence of environment and host on the rate and severity of disease development.

C. Determine the life cycle of the pathogen and develop control measures aimed at the most critical stages of its development, in coordination with RPA 404-E.

POTENTIAL BENEFITS: Identification of fruit and nut disease pathogens and knowledge of their life cycles and means of dissemination will suggest measures for the most satisfactory and economical control of the diseases that they incite.

RECOMMENDED RESEARCH EFFORT:

TF Recommendation (Scientist Man-Years)	
1972	1977
15	18

RPA 205-E Development of new Techniques, Equipment, and Chemical Formulations for Applying Fungicides, Bactericides, and Nematicides

SITUATION: Many factors limit the efficient use of chemicals for plant disease control. Promising new chemicals have not survived the developmental stage due to formulation problems, phytotoxicity, and other factors incompatible with present application methods. Formulations cannot be changed from the present wettable powders, emulsifiable concentrates, granulars, or dusts, until there are innovations in application. Likewise, application techniques cannot be modified appreciably until new formulations are developed.

OBJECTIVE: Improve disease control by developing improved chemical formulations and techniques of application of fungicides, bactericides, and nematicides.

RESEARCH APPROACHES:

A. Develop new concepts of formulation and application techniques (low and ultra-low volume, capsulation of chemicals, electrical charge, drift control, etc.) for chemicals to be used for disease control.

B. Reevaluate and examine chemicals under A that have demonstrated superior biocidal activity but have not qualified under the present day developmental structure.

C. Make compatibility studies with other pesticides.

D. Coordinate research with RPAs 204, 206, and 404-E.

POTENTIAL BENEFITS: Improved disease control for fruit and tree-nut crops particularly during severe epiphytotics: new techniques will bring more efficient use of and more effective disease control chemicals.

RECOMMENDED RESEARCH EFFORT:

TF Recommendation (Scientist Man-Years)	
1972	1977
30	35

RPA 205-F Development of new Bactericides, Nematicides, and Fungicides and Determination of their Modes of Action

SITUATION: Federal and State agencies are not usually involved in the synthesis of new disease control chemicals. This area of research is primarily in chemical industry. If the economics of an area does not warrant investigation, then it is neglected. Very little is being done on the development of new bactericides. The result is that no new bactericides are in the developmental stage at this time other than one or two antibiotics. This is a deplorable situation. Recently, several chemical companies concluded that fungicide and nematicide development was not economically feasible and have discontinued or greatly curtailed such programs. Federal and State agencies need to initiate chemical development studies and increase studies on mode of action of chemicals

in development areas being neglected by private industry.

OBJECTIVE: Develop new bactericides, fungicides, and nematicides, and study their modes of action.

RESEARCH APPROACHES:

A. Evaluate new chemicals for biocidal activity using screening techniques against fungi, bacteria, and nematodes.

B. Study the mode of action of new chemicals of biocidal efficiency plus many that are now in use.

C. Coordinate research on a regional basis with RPAs 204, 206, and 404-E. Such a program needs coordinated effort involving plant pathology, entomology, plant physiology, chemistry, agronomy, horticulture, and agricultural engineering.

POTENTIAL BENEFITS: New and more effective chemicals for control of fruit and tree-nut crop diseases and other pests.

RECOMMENDED RESEARCH EFFORT:

TF Recommendation (Scientist Man-Years)	
1972	1977
45	53

RPA 205-G Physiological and Biological Control of Fruit Diseases

SITUATION: Little attention has been given to the specifics of disease control by manipulating host physiology, although a few experiments indicate that some degree of disease control by such means may be possible. Quite recently, the application of certain bio-regulants (Giberellins) was found to improve fruit yields significantly on cherry trees infected with cherry yellows virus by stimulating bud differentiation, usually depressed by virus infection. The effects of plant nutrition on rate of development of fungal and bacterial diseases have frequently been observed.

Biological control of some plant diseases, either by competing, non-pathogenic organisms or through super-parasitism, is a well-established phenomenon, but the degree of control achieved is often noneconomic. Some pioneering research is needed in the area of biological control,

particularly in the area of soil biology (RPA 205-B) and soil management to evaluate effects of competing organisms on important soil-borne pathogens of fruits.

OBJECTIVE: Induction of disease resistance or amelioration of injurious effects of plant diseases through alteration of host physiology by supplementary applications of bio-regulants and related substances. Assessment of the practicality of disease control through biological parasitism or competition by other naturally occurring, nonpathogenic organisms.

RESEARCH APPROACHES:

A. Test effects of bio-regulants and related compounds for inducing resistance to plant diseases or in compensating for injury from such diseases, particularly diseases of virus origin.

B. Determine the usefulness of biological competition or hyper-parasitism in control of fruit pathogens.

POTENTIAL BENEFITS: Control or amelioration of virus diseases in infected trees via bio-regulant applications could increase fruit yields and tree longevity. Successful biological competition would reduce disease severity and might increase the general effectiveness of other control measures.

RECOMMENDED RESEARCH EFFORT:

TF Recommendation
(Scientist Man-Years)

1972	1977
15	18

RPA 206 - CONTROL OF WEEDS AND OTHER HAZARDS IN FRUIT AND TREE NUT PLANTINGS

INTRODUCTION: Losses from competition with weeds, pilferage by birds, tree damage from rodents and deer and injury by frosts take an annual toll through direct losses and increased production costs. Damage from birds is an increasing threat and often causes complete loss of crop. Generally suitable fruit growing areas are limited by climatic factors, but all areas are subject to periodic inseasonal frosts. Protection of orchards and small fruit plantings by heating or other methods for one or two nights can often mean the difference between an adequate crop and complete loss. Deer and rodent damage are insidious losses which growers suffer because of lack of effective controls. Losses due to competition from weeds have been underestimated and must be equivocated with the need for cover crops in soil management to prevent erosion and maintain proper nutritional levels.

Research has been directed to the more obvious problems of varietal improvement, pest control, nutrition and orchard management and research on weed control and other hazards has been neglected. Losses are extensive and often catastrophic; frosts alone have wiped out crops in whole areas. New technology in other fields has shown that research could develop information which would enable growers to prevent such losses. Benefits would be reflected in increased returns to growers, improved economy in fruit growing and reduced costs to consumers.

RPA 206-A Control of Weeds in Fruit and Tree Nut Crops

SITUATION: Weeds and cover crops compete with all fruit crops and nut trees for soil moisture and nutrients often resulting in decreased quality and yields. Mechanical weed control is expensive and damages roots near the soil surface. Effective chemical herbicides have been developed but many have some undesirable features. Fruit, including small fruit, and nut tree species and varieties, within a crop differ in their tolerance to herbicides and in the amounts of such chemicals they absorb. Some herbicides have a short half-life and readily disintegrate, whereas, others carry over and accummulate in soils complicating the problem of continued use. Some long-lived materials may eventually get into drainage water and contribute to environmental pollution.

Cover crops are essential in some orchards. Their use, however, needs to be integrated with cultural and weed control practices to serve their purpose with the least detriment to orchard crops. The national research effort on the control of weeds in small fruit plantings and orchards is disportionately small compared with the losses they cause or the

improvement in production that could result from effective control.

OBJECTIVE: Develop an integrated program of weed and cover crop control which will minimize competition with fruit crops and provide an adequate cover to prevent erosion and permit suitable soil management.

RESEARCH APPROACHES:

A. Determine the chemicals which will give best control of a wide spectrum of common weeds without injury to the various fruit and tree nut crops. Determine any possible residues in edible portions.

B. Determine optimum dosage, time and methods of application, and study the effect of varying environment and cultural practices on the effectiveness and safety of herbicides.

C. Determine the most desirable types of cover crops and the most efficient management practices to afford good returns and minimum competition with the fruit and tree nut crops.

D. Coordinate with fate of herbicide studies in RPA 309 and management research in RPA 304.

RECOMMENDED RESEARCH EFFORT:

TF Recommendation (Scientist Man-Years)	
1972	1977
14	14

RPA 206-B Develop and Test More Effective Heating Devices and other Means for Frost Damage Prevention in Fruit and Tree Nuts

SITUATION: Spring frosts in deciduous orchards and small fruit plantings and winter freezes in evergreens are an annual threat to fruit growers causing damage in some areas every year. Besides loss of crop, tree fruits tend to overbear the following year and develop an undesirable alternate bearing habit which is difficult to correct.

Usually cold exposure is of short duration and providing supplemental heat can prevent much of the crop loss. The need for orchard and vineyard heating is an old problem. Heat generated at the soil level rises rapidly and is lost to areas where it is most urgently needed. Many

devices have been developed. The most widely used heating equipment is the oil burning return stack heater in combination with propellor-type machines which help distribute heat in the orchard area. Recently new types of fuels, including pressed coal bricks, solid petroleum blocks, propane gas, etc., have become available. Small heat generators under the leaf canopy of citrus have shown promise. New types of heat deflectors to spread heat and reduce loss from the orchard areas have been developed. One of the big costs is labor for refueling, lighting and regulating equipment. Some of the new equipment may be more efficient than that currently being used but little valid information is available to evaluate this equipment. Some preliminary work has indicated a possible increase in frost hardiness through use of chemicals to retard blossoming or induction of biochemical resistance to cold.

Heating to alleviate frost and freezing injury has become an integral part of citrus culture in some areas of the United States. Greater efficiency in orchard heating could materially cut costs and stabilize production of fruit crops which are important to the American diet. The protection of small fruits from frost or freezing damage by overhead sprinkling, irrigation, or flooding is now a built-in component of successful production.

OBJECTIVE: Develop more effective, less expensive methods for protecting crops from frost and freeze damage.

RESEARCH APPROACHES:

A. Assemble and test new devices on the market for heat output, safety, engineering efficiency, and dependability.

B. Determine operational costs of the various devices as compared to standard equipment.

C. Study basic engineering to develop new, less costly, and more effective heating devices.

D. Evaluate biochemical induction of frost hardiness and determine its feasibility.

E. Coordinate with biological efficiency studies 304, disease control research 205, and environmental pollution 901.

RECOMMENDED RESEARCH EFFORT:

TF Recommendation (Scientist Man-Years)	
1972	1977
10	13

RPA 206-C Develop Improved Methods of Rodent, Deer, and Bird Control

SITUATION: Rodents cause extensive losses to fruit orchards. Rabbits damage young trees and nursery stock. Field mice girdle older trees, especially during the winter months when there is a snow cover. Presently available poisons are only partially effective. Bird damage to fruit is becoming increasingly severe near urban areas. Bird control is difficult because of public sentiment and it is difficult to find measures which are specific to marauding species. Deer cause damage to nursery stock and to orchards, especially in areas near native vegetation which provides natural cover. Conservation provisions limit destruction of deer, but practical means have to be found to prevent them from damaging crops.

OBJECTIVE: Find new, safe, and economic methods of control.

RESEARCH APPROACHES:

A. Develop a broad testing program to find chemicals for safe control of rodents.

B. Restudy the life cycle of the field mouse to find possible biocontrol means.

C. Explore new methods for selective elimination of marauding species of birds. Find new methods of repelling fruit eating birds from orchards and small fruit plantings.

D. Expand research to find repellants for deer. The sport minded public will not countenance any measures which will reduce deer populations substantially.

E. Coordinate with control of fruit diseases 205.

RECOMMENDED RESEARCH EFFORT:

TF Recommendation
(Scientist Man-Years)

1972	1977
6	8

NFA 304 - IMPROVEMENT OF BIOLOGICAL EFFICIENCY OF FRUIT AND TREE NUT CROPS

INTRODUCTION: The research program proposed in this section provides for the origination or development of new and improved varieties of fruits and tree nuts, and for the origination or development of management practices that will provide for maximum economic production from available crop varieties. The program provides for field, greenhouse, and laboratory research. Much of the latter is basic in nature.

The variety improvement program proposed entails a search for plant materials having economically valuable genetic attributes, and combination and recombination of these genetic attributes so that new varieties, when finally released, will combine as many valuable attributes as possible. The accomplishment of this objective will require not only field screening of large numbers of individual plants, but also utilization of the basic techniques of genetics.

For the short term, the program outlines necessary research for maximum exploitation of the genetic potential of presently available varieties. Proposed below are studies of planting distances, pruning, soil physical structure and fertility, bio-regulants, and manipulation of the environment. Studies proposed are not only for field experimentation, but also for greenhouse, growth chamber, and laboratory research. Accomplishment of these missions will require utilization of the most advanced techniques of the plant physiologist and biochemist, as well as the knowledge of the horticulturist, soil chemist, physicist, and agricultural engineer.

The benefits will initially accrue to the farmer, who will be able to plant varieties with inherited potentials in excess of those obtainable now. Further, he will have available to him management techniques which are optimum for his set of environmental conditions, and he will be in possession of techniques to favorably modify the environment. The ultimate beneficiary of this and other agricultural research will be the American public. Without the continuation and expansion of the research proposed here, the consumer will not continue to enjoy an abundant supply of reasonably priced fruits and nuts.

Estimates of the benefits to be obtained from research are at all times subjective, since the conduct of research carries no guarantee of an economic return. The history of research in this area, however, presents ample reason for being optimistic that the proposed research will in fact be economically beneficial. For example, fertility research in central Florida has made possible the establishment of a large fruit industry on

extremely infertile soils. The peach variety development program has provided a succession of varieties to which the present peach industry owes its existence. The assumptions that there are still many opportunities for improvement, some not foreseen immediately, and that there are many problems demanding solutions seem reasonable. For example, a pressing problem today is the need for effective and economical abscission chemicals, which together with suitably spaced and pruned tree fruits and appropriate machinery may greatly expand mechanization of tree fruit harvesting. Equally challenging are the problems with grapes and small fruits. New programs in varietal development for adaptation to harvest mechanization must be coupled with changes in culture and training. State and Federal expenditures for research in this area in 1966 were $8.5 million (from An Inventory of Agricultural Research, Vol. I, Table 1, pages 68 and 69. June 1967). The farm value of the 24 principal fruits and tree nut crops in 1965 was $1.56 billion. The expenditure for research in this area, therefore, was 0.5 percent of the value of the crop. When placed in this context, the continuation of the current program plus the modest expansion outlined below will very likely yield an excellent return on the investment of tax funds.

RPA 304-A Improving Biological Efficiency of Fruit and Nut Crops by Genetics and Breeding

SITUATION: Except for breeding or selection, few fruit crops would be grown commercially today. The continual occurrence of new strains of disease organisms and insects, changes in cultural practices, and increasing demand for higher quality fruits and fruit products create a strong demand for new fruit varieties adapted to variable needs.

A wide spectrum of disease organisms attack fruit crops. Some of them can be controlled by chemical treatments, but the introduction of such chemicals into the environment often is considered potentially hazardous to man and other life forms. Further, for successful use of chemicals, timing of applications is critical and often obstructed by weather conditions. Use of chemicals to control diseases, insects, and other pests may constitute 10 to 20 percent of productions costs. For some very serious fruit diseases, no practical control measures are known except for biological resistance.

Fruit yield and quality are often highly responsive to cultural practices, but limited in expression by genetic capacities of a variety. As new varieties are developed, yield and quality must be maintained at a high level.

Probably no factor is as important currently as mechanizing fruit production, harvesting, and handling. The time is rapidly approaching when those fruit crops which cannot be adapted to mechanization will only be grown as high-cost specialty items. The strong trend toward greater

mechanization of fruit production will necessitate in most cases drastic modification of inherent plant and fruit characteristics. Since essentially all tree fruit varieties are propagated vegetatively, rootstocks which are genetically adapted for specific uses can be exploited to a much greater advantage. Because breeding is a relatively long term and costly endeavor, increasing the efficiency of breeding methods and evaluation techniques is greatly needed. Basic genetic systems need to be studied in the development of more efficient breeding systems.

OBJECTIVE: Develop fruit varieties that consistently yield large crops of high-quality, attractive fruit which are adapted to mechanized cultural, harvesting, and handling techniques; improve breeding methods and evaluation techniques.

RESEARCH APPROACHES:

A. Identify and accumulate genetic materials potentially useful for breeding or genetic studies.

B. Initiate breeding programs or modify existing ones to have as their primary objective(s) one or more of the following characteristics: disease, insect and mite resistance, fruit yield and quality, adaptation to environment, adaptation to mechanized production, and rootstock development.

C. Conduct genetic studies to increase efficiency of breeding methods.

D. Increase utility and efficiency of breeding techniques and methods of plant and fruit evaluation.

E. Coordinate programs with 204-D, and 205-A.

POTENTIAL BENEFITS: Increased yields of high-quality fruit adapted to mechanized production and handling. Increased efficiency of breeding.

RECOMMENDED RESEARCH EFFORT:

TF Recommendation (Scientist Man-Years)	
1972	1977
103	123

RPA 304-B Spacing, Training, and Pruning

SITUATION: Conventional practices for spacing, training, and pruning fruit crops were developed when choice land and labor were abundant. Today, land suitable for fruit production is very expensive and must be made highly productive if costs are to be justified. Fruit growers also find themselves in direct competition with industrial, housing, and highway developments for choice sites, often losing to these interests and settling for less desirable or marginal sites. Desirable labor is becoming less available and is not inclined to accept working conditions less favorable than those offered by competing industries.

Developments in both labor and land favor intensification of production on existing available land. The maximum effective number of plants must be planted on each acre. These plants must be arranged on the land, trained, and pruned to effectively utilize light, water, and soil resources for highest fruit quality and maximum yield. They must also be trained and pruned into special forms adaptable to mechanization of the operation, particularly for harvesting. These are new specialized characteristics not formerly of importance.

OBJECTIVE: Determine spacing distances and pruning and training practices that will permit maximum utilization of land and maximum utilization of machinery while improving fruit quality and yield. Determine scion and rootstock combinations most adaptable to intensive cultivation.

RESEARCH APPROACHES:

A. Determine the spacings of fruit plants that will produce maximum yields of high quality fruit over the entire life of the planting. Studies should be conducted on those soils likely to be available for fruit production in the future.

B. Determine the spacings necessary to permit maximum utilization of machinery and minimum use of hand labor in fruit production.

C. Determine the best methods for utilization of mechanical pruning equipment so as to maximize fruit quality and yield, and insure the health and longevity of the fruit plants.

D. Determine the minimum size and the shape of mechanically pruned fruit plants that will permit maximum yield of high quality fruit.

E. Determine the spacing, pruning, and training requirements imposed on fruit plantings by existing or new mechanical harvesting equipment. Determine losses in biological efficiency resulting from these restrictions and develop techniques to minimize adverse effects.

F. Evaluate rootstock and scion varieties of tree fruits on the basis of adaptability to pruning, training, and spacing requirements in mechanized agriculture.

G. Coordinate with research in RPA 305 and RPA 306.

POTENTIAL BENEFITS: Increased yields of high quality fruit from each acre devoted to fruit production. Partial solution of the labor problem in fruit production.

RECOMMENDED RESEARCH EFFORT:

TF Recommendation
(Scientist Man-Years)

1972	1977
30	30

RPA 304-C Soil Management and Nutrition

SITUATION: Research in soil and water management, plant nutrition, and fertilizers has contributed greatly to the past and present productivity of fruit crops. However, much research needs to be done to increase efficiency of production of varieties in use and those to be developed. The standardization of diagnostic techniques, for mineral element deficiencies and toxicities using well designed field trials as primary standards, has yet to be accomplished for some major fruit crops. Research in irrigation management in both arid and humid regions can lead to increased production efficiency, economies in water use and, in some cases, greater return from other production inputs. Much remains to be done to identify the effects of specific nutrient elements and water management practices on fruit quality and harvesting efficiency, either by hand or by machine. When cultural practices are intensified, soil management and plant nutrition research are needed to determine optimum inputs for the new conditions encountered. In many areas, in response to migrations of people, expansion of urban areas and increased demand for food, new soils will be used for fruit production. Some of these soils will have conditions adverse to fruit crops and will require development of new management techniques such as physical manipulation, leaching or chemical treatment.

OBJECTIVE: Determine proper soil management and mineral nutrition for efficient production of fruit crops of the quality essential for marketing in fresh or processed forms.

RESEARCH APPROACHES:

A. Cooperate and coordinate with efforts of scientists in RPAs 102, 205-B, and 901 for maximum development and application of information to fruit production.

B. Determine rates, grades and time of application of fertilizers essential for pollination and fruit set and for the production of fruit with quality suited for mechanical harvesting, for the fresh fruit market and for processing.

C. Investigate spray application of fertilizer elements to fruit crops as a means of precision control of fruit quality and more efficient use of resources.

D. Develop soil and plant analysis as diagnostic techniques for determination of mineral element deficiencies and toxicities.

E. Determine methods for correcting adverse chemical properties of subsoils that limit fruit production or make some soils unsuited to fruit production.

F. Develop methods of management of land surfaces for the establishment of adequate water infiltration and for the support of mechanical equipment.

G. Develop methods of mechanical modification of adverse soils to make them more suited to fruit production.

H. Determine the optimum irrigation management for irrigated regions for control of fruit quality and for maximum benefit from other production factors.

I. Determine the circumstances in which supplemental irrigation can be beneficial to fruit production in humid regions.

POTENTIAL BENEFITS: Increased yields; higher quality of fruit adapted to efficient harvesting; more efficient use of water, fertilizers and soil amendments; use of presently marginal soil resources for efficient fruit production.

RECOMMENDED RESEARCH EFFORT:

TF Recommendation (Scientist Man-Years)	
1972	1977
54	60

RPA 304-D Physiology and Biochemistry

SITUATION: The performance of present fruit crop varieties is far from ideal. Wide fluctuations in yields from year-to-year demoralize price structures and marketing operations. The selection and breeding of improved varieties must be considered a very long-range undertaking. The requirements of a fruit industry often change more rapidly than varieties can be developed to meet the needs. For these reasons, maximum efforts must be made to influence present varieties to produce the desired high yields of high quality fruit every year, and to take vegetative forms and sizes that will facilitate mechanization.

Some improvement in performance can be obtained through the empirical approaches in RPA 304-B, C, and E. However, in many cases these empirical approaches fail for lack of information about the physiology and biochemistry of the crop plant. Carefully selected areas of research in these fields may provide a basis on which new cultural practices can be developed.

Some problems common to many fruit crops include low temperature injury, premature bloom development with susceptibility to spring frosts, failure to bloom, excessive drop of blossoms and fruit before harvest, alternate bearing, small fruit size, and undesirable fruit color. It is reasonable to believe that intensified study of the physiology and biochemistry of related plant metabolic processes will produce leads that can be developed into improved commercial practices.

The study of the action of applied chemicals and their fate in plants should be emphasized. The agricultural chemical industry is investing large amounts of resources in synthesizing compounds that regulate plant metabolic processes, growth, and development. This effort should be capitalized on to the greatest possible extent.

OBJECTIVE: Achieve a greater knowledge of the physiology and biochemistry of vegetative and fruiting processes and relate to increased biological efficiency.

RESEARCH APPROACHES:

A. Investigate the biochemical changes occurring in fruit crop

plants as they develop and lose dormancy or cold hardiness. Seek to modify metabolic pathways in economically desirable ways.

B. Investigate the biochemical changes occurring during blossoming and fruit set, and attempt to devise methods to control the amount and time of appearance of blossoms and the amount of fruit set.

C. Investigate the metabolism of fruit color development. Seek to modify these processes in economically desirable ways.

D. Investigate the metabolism of the abscission process, with the objective of being able to reduce the strength of the attachment between stem and fruit, thus facilitating mechanical harvesting.

E. Determine the physiological basis for effect of rootstock on scion varieties.

F. Test bio-regulants or growth-regulating chemicals on fruit crop plants. The screening should consist of thorough exploration of the effects of all chemicals known to modify growth, development, or metabolism of any fruit plant.

G. Coordinate closely with efforts in RPA 304-B, C, and E, and RPA 305.

POTENTIAL BENEFITS: Attain a greater degree of control over the performance of fruit crop plants, with potential of delivering better quality raw products to the trade on a fixed schedule. Reduce the fluctuation in yield and quality from year to year.

RECOMMENDED RESEARCH EFFORT:

TF Recommendations
(Scientist Man-Years)

1972	1977
115[a]	130[a]

[a]Includes 10 SMY from RPA 402

RPA 304-E Modification of Environment

SITUATION: Continuing reduction in available prime agricultural land due to urban and industrial expansion emphasizes the need for improving production and quality of products particularly fruits essential to a balanced diet. A relatively new aspect of farm management is the modification of the environment. The desirability of controlling temperature, humidity, air movement, quality, etc., on plant production is receiving increased recognition. Losses in production through excessively high and low temperatures, frost hazards, sand storms, etc., present major problems. Simple examples of environment modification are: (1) The growing of a few rows of barley between asparagus beds to reduce wind velocities at the ground level and improve crop quality and yield. (2) The employment of sprinkler systems to cool vineyards under extreme temperature conditions. Weather modification on both small and large scales present possibilities of enormous improvement in biological efficiency. At present much of the work is in the laboratory. This must be expanded to the field.

OBJECTIVE: Investigate the major factors of the environment in which fruits grow and develop systems by which these factors may be used to improve the biological efficiency of plants through increased efficiency of mechanical production and handling systems.

RESEARCH APPROACHES:

A. Determine the physical properties of the environments and evaluate their relations to mechanical systems.

B. Define criteria by which the modifying factors (of environment) may be employed in machine design.

C. Develop mechanical components and systems which will utilize the benefits of environment modification in terms of fruit production.

D. Coordinate with studies in RPA 109, 214, 301.

POTENTIAL BENEFITS: Control of modification of the environment in which plants grow will result in higher yields, improved product quality, and market stabilization. It can also reduce losses of product now experienced due to lack of environmental control.

RECOMMENDED RESEARCH EFFORT:

TF Recommendations
(Scientist Man-Years)

1972	1977
7	20

RPA 305 - MECHANIZED HARVESTING AND HANDLING OF FRUIT CROPS

SITUATION: In 1966 the United States produced over 22 million tons of fruit with a farm value of approximately 2 billion dollars. The major position of this tonnage - 2/3 of deciduous and small fruits and 80 percent of citrus fruit - was processed. The principal cost of production of these crops is represented by the harvesting operations. The diminishing supply of adequate farm labor as well as increasing labor costs are creating serious problems for the farmers of the country. Continued production cost increases will mean higher prices to the consumer and the possible disappearance of important diet constituents from the market. Mechanization can reduce production costs by modification of plant-machine relation and by increasing the efficiency of the farm worker. These factors all emphasize the need for continued research and development in the area of machines and mechanical systems to aid fruit crop production.

OBJECTIVE: Develop mechanized systems and equipment for harvesting and handling fruit for both processing and fresh outlets that will result in reduced labor requirements and costs while maintaining product yield and quality.

RESEARCH APPROACHES:

A. Determine physical properties of fruit and plants which affect mechanical harvesting and handling.

B. Develop machines and mechanical systems for harvesting and handling fruit.

C. Investigate automatic machine operations.

D. Develop mechanical aids and methods for increasing the efficiency of hand harvesting operations in crops which are not adaptable to completely mechanical harvesting.

E. Coordinate with RPA 403, 404 and 501.

POTENTIAL BENEFITS: Benefits of this type of research are directly reflected in more realistic returns to the farmer and the agricultural community and in reduced costs to the consumer.

RECOMMENDED RESEARCH EFFORT:

TF Recommendation
(Scientist Man-Years)

1972	1977
45	50

RPA 402 - PRODUCTION OF FRUIT WITH IMPROVED CONSUMER ACCEPTANCE

This RPA was assigned to the Fruit Task Force by the Research Program Development and Evaluation Staff.

The members of this Task Force believe that the use of such a subdivision is unrealistic and detrimental to the objectives of fruit research.

It is unrealistic in that traditionally, fruit quality has always been a principal criterion of success for applied research in insect control, disease control, nutrition and soil fertility, water management, and biological efficiency (RPAs 204, 205, 304, 305, and 105). The objective of RPA 402 cannot be separated from objectives of the other RPAs.

It is detrimental to the fruit research program in that it would de-emphasize the attention now given to fruit quality by established research programs. It would tend to suggest the need to establish competing research groups whose research approaches would be very similar. The resulting duplication of effort is not necessary or desirable.

The Fruit Task Force has incorporated the manpower requirements of RPA 402 into its recommendations for RPA 304.

RPA 403 - NEW AND IMPROVED FRUIT PRODUCTS

INTRODUCTION: An abundant supply of nutritious and aesthetically desirable fruits at reasonable cost is required to provide tasteful balanced diets. Fruits are perishable and seasonal and thus subject to supply and price fluctuations to the disadvantage of consumers and producers. Processing offers a way to avoid these fluctuations and to improve the diet of consumers.

Advance contracting between growers and processors helps provide a way for avoiding the disaster of price-shattering surpluses at harvest time and at the same time assures consumers of adequate food supplies at reasonable prices.

In order to expand markets and stabilize prices, new and improved processed products are needed for domestic and foreign markets -- products that incorporate quality, convenience, stability, nutrition, wholesomeness, and economy.

An important factor to consumers for home and away-from-home feeding is the preparation time and effort. In food service establishments the nearly complete shift to dehydrated, canned, chilled, concentrated, and frozen fruits exemplifies the ready acceptance of labor-saving products in commercial enterprises. Wide acceptance of these products could save billions of hours of homemakers' time per year.

Processing research can help accelerate the increasing trend in use of processed fruits. In 30 years the portion of the fruit crop processed has increased from practically none to over half. This trend has made possible a shift in fruit production from areas near large centers of population to more efficient growing areas in the country. (For example, nearly 100 percent of some fruit and nut crops for processing are grown in the far western states.) Processing stabilizes the quality and food value of fruit while reducing freight costs and product waste so that during most of the year processed fruits are lower priced per serving than fresh. At the same time they are nutritious, desirable, and more convenient to prepare for serving.

While aesthetic qualities of preserved products are almost always different from fresh, very acceptable quality is available for many processed fruits. Research is constantly improving consumer acceptance of products by developing new and better products and preservation methods. Constant attention is needed to develop novel methods that will further reduce costs involved in stabilizing and preserving inherent qualities of fruits from the farm to the consumer.

Over 26 billion pounds per year of deciduous fruits,berries, citrus, and subtropical fruits are processed into products and made available in markets distant from growing areas. Conversion of perishable products to stable processed ones helps provide in times of over-production for more orderly marketing. Much larger fruit crops are expected in the future and judging by previous experience, a larger fraction will need be manufactured into high quality products. Improved technology of food processing is needed to accomplish this in an efficient manner.

Commercial processing firms, with a few exceptions, are organizations limited in size and financial means and do not usually have the resources to conduct a significant amount of basic research. They depend for much of their basic research on the Agricultural Experiment Stations, the U.S. Department of Agriculture, and the National Canners Association. When basic research is done by these organizations, duplication of effort can be avoided and greater progress can be made with the same amount of money.

The primary objective of Government research is to solve the more complex biological and engineering problems associated with originating a new fruit product or combination so that commercial firms can make use of this knowledge in their development and introduction of a new product.

RPA 403-A Development of Improved Techniques for Preservation and Stabilization of Processed Fruit Products

SITUATION: Fruit crops are perishable, seasonal, and subject to price fluctuations according to supply and climatic conditions. These fluctuations, which can be quite sizeable, are to the disadvantage of the producer as well as the consumer and steps should be taken to stabilize these markets. Stabilization can result from new and improved fruit processing which will yield superior quality, nutritious and wholesome products with greater stability and convenience at low costs.

Deciduous fruit and berry crops are harvested in relatively short periods of time. Fruits offer special advantages such as flavor, natural texture, color and other desirable characteristics, and processing methods need be modified to retain more of these fresh fruit characteristics without losing nutritive advantages. Dehydration of these materials under proper conditions can provide improved storage stability.

Many specialty fruits and berries have specific delicate characteristic flavors or novel nutritive advantages which cannot be enjoyed to the fullest extent by consumers in distant markets due to the instability of these products during storage and marketing. Development of improved techniques for processing these fruits and berries could broaden their markets and make their nutritional advantages available to the general public.

OBJECTIVE: Devise improvements in presently used methods of processing and develop new processing methods to provide high quality, stable, fruit products at minimum cost, and provide greater market stability, consumer satisfaction, and broader markets.

RESEARCH APPROACHES:

A. Conceive and develop new processes and adapt existing ones for producing dehydrated products from fruits and berries yielding products which can easily be reconstituted to forms having natural flavor, color, nutritional advantages and texture.

B. Improve the process of dehydrating fruit purees and juices with a minimum loss of color and flavor.

C. Develop and extend special dehydration processes such as foam-mat drying and freeze drying for utilization in preparing dehydrated liquid form foods such as frozen citrus concentrates, or fruits and fruit parts which can be put to novel and unique use.

D. Devise new methods and techniques for stabilizing fruit products through improved methods of enzyme inactivation.

E. Improve methods for processing fruits to improve color, texture, or appearance in the processed product and minimize changes during storage and distribution.

F. Improve storage stability of nonfrozen fruit juice products so that they may be shipped greater distances without additional costs for refrigeration and special handling.

G. Improve fruit processing techniques to minimize microbial contamination and improve sanitation.

H. Develop changes and improvements in conventional and new processing techniques as necessary to adapt them for use on mechanically harvested fruit or on special fruit varieties developed for mechanical harvesting. (Will be coordinated with RPA 305).

POTENTIAL BENEFITS: Stabilize prices, increase income to fruit growers and processors, and increase availability of wholesome, nutritional advantages of fruits to a broad segment of the population while lowering costs to the consumer.

RECOMMENDED RESEARCH EFFORT:

TF Recommendation (Scientist Man-Years)	
1972	1977
48	61

RPA 403-B Development of New Products and Byproducts from Fruit

SITUATION: Products need be developed for wider distribution to broader population segments which will make the fruits available for longer periods at reduced costs. New and improved fruit products in optimum form for consumption can provide these benefits. There is a great potential for higher consumption and better utilization of fruit products and nonfood byproducts if imagination and ingenuity are used to seek out new markets. Some potential expansion areas are: (1) improved light-weight, convenience products for the ever expanding air travel markets, (2) appealing and stable fruit products for vending machines, (3) enzymes for home and industry from fruit byproducts and wastes, (4) conversion of fruits and fruit wastes into specific chemical products which have unique or novel food or nonfood uses.

Citrus and other fruit products are needed which will utilize more completely the entire fruit, thus minimizing waste and maximizing marketable portions. Products need be developed to exploit the special attributes of particular fruits, such as color, delicate or unusual flavors, aroma, etc. Development of these new products require new and improved processing techniques as well as a better understanding of the basic chemistry and biochemistry of fruit, color, texture, and flavor.

New products rapidly replace old ones and to remain competitive it will be necessary to replace about 25 percent of present fruit products by 1977.

OBJECTIVE: Develop unique and novel products as well as improvements in existing products which exploit specific characteristics of fruits to increase markets and make these special attributes widely available to the general public.

RESEARCH APPROACHES:

A. Develop novel and unconventional forms for dehydrated fruit products which can be used in expanding markets rather than substitution for other products from similar commodities.

B. Develop new and improved products from fruits and berries utilizing as much of the complete fruit as possible, minimizing waste and maximizing nutritional advantages.

C. Develop new and improved fruit products which exploit novel color and nutritional aspects, particularly with regard to highly pigmented fruit such as Ruby Red grapefruit, blood oranges, some early oranges, certain types of berries and the like.

D. Develop new chemical byproducts which can be derived from novel or unique components of fruits and fruit wastes with potential for use in broad market areas, such as synthetic sweeteners from citrus flavonoids, enzymes from various fruits, pectic products for use as blood extenders and the development of blood anticoagulants from natural flavones.

POTENTIAL BENEFITS: Make the nutritional advantages of fruits available to wide segments of the population at stable economical prices on a year-round basis.

RECOMMENDED RESEARCH EFFORT:

TF Recommendation (Scientist Man-Years)	
1972	1977
34	44

RPA 403-C Quality Improvement and Characterization of Processed Fruit Products

SITUATION: The most important characteristics of fruit products are odor, flavor, color, texture, nutrient content, and general eye appeal. Flavor is derived largely from fruit oils or essences, the levels of which may vary from one variety to another and between processing systems. Variations occur in natural constituents such as enzymes, vitamins, ribonucleotides, lipids, and color. Some compounds may be responsible for undesirable effects such as bitterness, and off-flavors in the products.

In order to assure desirable qualities with a minimum of undesirable effects in fruit products, the true composition of high quality fruit products should be characterized as completely as possible. This requires studies of the chemical and biochemical nature of physical properties of

desirable fruit products, as well as undesirable fruit products so that products of uniform high quality can be manufactured. Chemical and physical data are required to provide measures by which quality of fruit products may be gauged accurately to provide precise guidelines when changes in equipment and processing practices are made, in order to still maintain high quality.

If means were available for readily determining all important chemical and physical factors related to quality, the information would be valuable in many ways. For instance, it would be valuable in judging the effects on quality, of changes in processing which would increase yield, increase capacity, or use different grades of fruit. It would permit best use of fruit of different maturities from different varieties or that which has been injured as by freezing.

Basic information is needed on the enzyme systems present in harvested fruit and the effects of these enzymes on quality of products. Advantage may be taken of some enzyme systems to improve quality but in most cases where deterioration would be expected, information is needed on how best to keep deterioration at a minimum. Knowledge of the identify and characteristics of enzyme systems of influence in frozen fruit and mechanically harvested fruit is needed to guide processors in packing products of high quality.

Previously, many decisions regarding processing of fruit had to be made on the basis of taste, appearance, or arbitrary observations. Progress has been made employing these methods but techniques are being developed whereby better and more precise decisions can be made based on definite chemical, biochemical, and physical knowledge.

By 1977 it is anticipated that over 30 billion pounds of fruit products will be produced per year and the research in this area will help assure good flavor, nutritive qualities, and wholesomeness.

OBJECTIVE: Define characteristics which identify excellence and consumer desirability of processed fruit products. Provide composition and physical property data on fresh fruit to use as guidelines or indices for maintaining high quality and uniformity. Provide compositional and physical property data on undesirable qualities to use as guidelines for identifying needed improvements or up-grading quality of products.

RESEARCH APPROACHES:

A. Establish the identity of chemical compounds in fruit products and establish their relationship to quality, especially to flavor, appearance, and nutritive value to assure that fruit

products will be attractive and satisfy dietary requirements.

B. Establish the nature of the chemical and biochemical reactions in fruit products after manufacture to insure that these products reach the consumer with optimum flavor and nutritive quality.

C. Develop information on the biochemical properties of fresh fruit being used for processing, especially of enzyme systems, ribonucleotides (known to affect flavor) and other biological systems which could affect quality and nutritive value.

D. Relate quantitatively the collective chemical, biochemical and physical characteristics which define high quality processed products and develop methods of using these data as indices of quality and uniformity in fruit products.

E. Develop specific chemical and physical methods for the detection of adulteration of fruit products including the addition of unauthorized materials.

F. Research along these lines will benefit other areas, such as improvement of biological efficiency of fruit crops (RPA 304), mechanization of vegetable crop production (RPA 305), production of fruit crops with consumer acceptability (RPA 402), and physical and economic efficiency in marketing fruits (RPA 503).

POTENTIAL BENEFITS: Improved quality and uniformity in fruit products; improved methods of detecting degradation during storage and transit; expanded use of processed fruit products for flavor and convenience; more nutritious diets possible because of the availability of wholesome, uniform high-quality fruit products.

RECOMMENDED RESEARCH EFFORT:

TF Recommendation (Scientist Man-Years)	
1972	1977
73	93

RPA 403-D Evaluation of Processing Characteristics of New Fruit Varieties

SITUATION: New fruit varieties need to be evaluated for their suitability for processing. Many plant breeding programs in the past have been designed to produce new varieties with improved qualities for fresh market use or to produce varieties which mature at different times. In some cases there has been a tendency to assume that if a fruit was suitable for fresh market use, it was also suitable for processing. Recent unfortunate examples include the introduction of the Marrs variety of round orange and the K-Early variety of loose skin oranges. These fruits may satisfy certain markets if there is nothing else available at the time. When they are processed, the situation is quite different as the products must compete directly with those from other varieties maturing at more favorable times during the year. In other cases, the fruit may be quite acceptable when eaten fresh but develops undesirable flavors when processed. For example, Washington navel oranges are excellent when eaten fresh but if they are processed into juice or concentrate, an extremely bitter flavor develops. Over 75 percent of the citrus crop is now processed. This is highly desirable since an outlet is provided for packing house eliminations (sound, but scarred or discolored fruit), or surplus fruit that cannot be marketed in fresh form. It is essential that each potential new variety be evaluated as early as practicable for its processing characteristics. Failure in this can result in the planting of varieties which are unsuitable for processing.

New varieties can be tested to determine whether they can be blended with the juice of other fruit without detriment to the product. Flavor is most important and must be checked carefully, but color is also of significance. In some cases the blending of limited quantities of juice from highly colored fruit can be advantageous. Specialty fruits of unusual flavor might be processed separately. While citrus fruits are used as an example, the same applies to many other fruits where a major portion of the crop is processed.

It is essential that new varieties of fruit be evaluated for processing prior to release and establishment of commercial planting, if a significant amount of the fruit might be offered for processing. This will afford protection to the growers as well as the processors and improve the general economy of the fruit industry.

OBJECTIVE: Evaluate the processing characteristics of each potential fruit variety or selection to provide processing research support for agricultural production and engineering research.

RESEARCH APPROACHES:

A. Evaluate the processing characteristics of new fruit varieties and selections for use separately or by blending with other varieties.

B. Evaluate the processing characteristics of new and established fruit varieties as affected by changes in cultural and production practices.

C. Develop new products and processing techniques to obtain maximum benefit from unique characteristics of new varieties.

D. Accumulate information on the chemical composition of new varieties to aid plant geneticists in selecting desirable traits, also to aid processors and regulatory agencies in the determination of proportions of the subject fruit in blends.

POTENTIAL BENEFITS: Provide knowledge of processing performance prior to commercial planting; new fruit products of improved color, flavor, and texture; improved profits to growers from utilization of the whole crop; and effective support of agricultural genetics, production, and engineering research.

RECOMMENDED RESEARCH EFFORT:

TF Recommendation
(Scientist Man-Years)

1972	1977
3	3

RPA 404 - QUALITY MAINTENANCE IN MARKETING

INTRODUCTION: Quality maintenance research with fruit deals with protecting and maintaining quality in all marketing channels. The work includes physiological, biochemical, horticultural, pathological and entomological problems encountered during handling, packing, storing, transporting, and distributing. Research emphasis must be continued to increase production and mechanization in the fruit industry; but, equally important, quality maintenance research must be accelerated to insure that harvested fruit reaches the consumer in good condition. The quality of highly perishable fruit may deteriorate rapidly and a portion of the crop may become unsalable. Wherever possible, improvements should be made without increasing marketing costs.

Although a large variety of high quality fresh and processed fruit products are available at reasonable prices throughout the year, there is need for further research on methods to reduce spoilage and waste during marketing. Many of the desirable quality characteristics that fruits possess at harvest may be lost by the time they reach the consumer because of moisture loss, unfavorable temperatures, bruising, and decay. Stored product insects, market diseases, and improper handling still destroy large amounts of fruit. There is urgent need for new methods of insect and disease control that will not create pesticide residue problems.

Prevention of spoilage and damage will give consumers a more attractive nutritious product and will eliminate the costs involved in discarding fruit that cannot be sold. In addition, good quality fruit will be available to consumers for longer periods. Extended storage may also provide increased returns to producers.

Estimates of marketing losses are incomplete. Prior to 1965, estimated average annual losses for fruit and tree nuts just during transportation, unloading, and retailing were $102 million 1/. A summary of these losses based on 1966 farm values and possible savings by 1977 are shown in the table. Percentage losses during storage for fresh market sale and during storage prior to processing are unknown for many fruits, but are high for berries and stone fruit. Even for apples, storage losses average about two percent.

1/ U.S. Dept. Agr., Agr. Handbook No. 291

Commodity	U.S. fob value 2/	Estimated losses 3/	Possible savings 4/
	-- Thousands of dollars --		
Apples			
Fresh market	222,000	8,000	2,000
Stored for processing	30,000	1,000	200
Avocados	17,000	300	150
Bartlett pears			
Fresh market	16,000	800	200
Stored for processing	34,000	2,000	500
Other pears (fresh)	16,000	8,000	300
Berries (fresh)	70,000	10,000	5,000
Grapefruit	91,000	2,300	600
Lemons	54,000	4,400	1,100
Oranges	338,000	15,000	3,700
Other citrus	19,000	1,000	250
Peaches and nectarines	175,000	22,000	15,000
Other stone fruit	68,000	6,000	3,000
Table grapes	30,000	7,000	4,000
Dried fruit	110,000	11,000	5,500
Tree nuts	144,000	3,000	1,500
Total per year	1,434,000	101,800	43,000

RPA 404-A Improved Handling and Packaging of Fruit to Maintain Quality

SITUATION: Fresh fruits and tree nuts deteriorate after harvest through normal metabolic processes, from decay organisms, and from insect infestation. When handling is rough or careless and packages or containers are inadequate for protection, products are injured and deterioration and resultant waste are increased. Mechanization of fruit harvesting, handling, and packing house operations has in many instances reduced costs but has also increased mechanical damage and incidence of decay. Such mechanical harvesting and handling is sure to continue to expand to add efficiency and make better use of labor. It now appears likely that within the next five years some oranges and grapefruit will be harvested mechanically into bulk bins; sorted automatically by color, grade, and condition; filled and weighed mechanically into shipping containers to consumer packages; and palletized for shipment and wholesale handling. Improved

2/ Based on 1966 data, Agricultural Statistics, 1967

3/ U.S. Dept. Agr., Agr. Handbook No. 291

4/ By 1977 through research proposed

procedures to minimize damage and maintain optimum quality are needed for this automated handling of citrus and other fruits. As mechanized harvesting, mechanized packing house systems and bulk handling procedures are perfected, physical damage to the fruit will decline.

Packages and containers of many types and sizes are in use; some merely unitize and provide little physical protection for the fruit during handling. Marketing studies in retail stores in California and in Michigan showed that about one-third of the apples offered for sale are bruised so badly that their appearance and quality are materially impaired. Improved packaging can also minimize moisture loss. Research is needed to study the extent of damage occurring in various new containers, and to determine the best palletizing and loading patterns to provide recommended refrigeration. Increase in export shipments by sea and air will require development of special containers to provide beneficial refrigeration and modified atmospheres to retard deterioration and reduce handling.

Research is necessary to develop more effective measures for preventing insect infestation of dried fruits and tree nuts during marketing. Insect-resistant packaging offers great promise. Emphasis must be given to finding methods that will avoid insect contamination and objectionable pesticide residues.

OBJECTIVES: Determine and evaluate those changes in handling and packaging which affect quality of fruit and tree nuts as they move from producer to consumer. Adapt or improve handling practices, packaging materials and containers to better maintain quality during marketing without unduly increasing costs.

RESEARCH APPROACHES:

A. Determine where bruising and other mechanical damage occur and how they can be minimized.

B. Evaluate new methods of product handling and protection that will best maintain quality at a reasonable cost.

C. Evaluate various containers which provide physical protection to the commodity, are compatible with rapid cooling and spaced stacking, are economical to use, and are acceptable to wholesalers and retailers.

D. Determine how present or developing systems of mechanized harvesting affect fruit quality. Develop acceptable postharvest preservative treatments to offset any harmful effects of mechanical harvesting.

E. Develop improved insect-resistant packaging for dried fruits

and tree nuts.

F. Determine optimum degreening treatments for early season harvest of oranges and grapefruit and improved ripening procedures for peaches, pears, plums, and subtropical fruit.

POTENTIAL BENEFIT: The research contemplated should provide more acceptable product quality at the consumer level; possibly resulting in increased consumption of fresh fruit, dried fruit, and nuts. Reduced wastage at wholesale, retail, and consumer levels resulting from improved handling and packaging should increase returns to the producer and reduce cost to the consumer. Improved handling and development of other techniques to retard deterioration should allow export of fruit to distant countries, thus aiding in the marketing of expanded production in future years.

RECOMMENDED RESEARCH EFFORT:

TF Recommendation
(Scientist Man-Years)

1972	1977
14	17

RPA 404-B Improved Storage of Fruit

SITUATION: Refrigerated storage is the major handling procedure used to retard both physiological and pathological deterioration of many fruits. Where adaptable, storage allows orderly marketing of the crop over many months of the year and minimizes waste. The farm value of deciduous fruits, grapes, and berries sold for fresh consumption was more than $280 million for the 1966 crop. Of this total, apples contributed more than half with grapes, peaches, and pears together accounting for about a third of the total. Fruits for processing account for another $430 million and those fruits which are stored for processing, such as apples, pears, and peaches, are still subject to significant wastage before processing.

As new acreage of citrus and deciduous fruit comes into production, the marketing season for them must be extended. As an example, the quantity of oranges available for fresh consumption will increase from 15.8 pounds per capita in 1965 to 22.4 pounds per capita in 1970. Unless major disasters strike the orange production areas, the quantity of fruit per capita will increase considerably more by 1975. As the storage season is extended for fruit, the related problems of wastage from decay and functional disorders will inevitably increase. Research on improved

storage and on supplements to refrigeration, such as use of controlled atmospheres and fumigation, must be expanded. Mechanical harvesting, bulk handling, and storage in pallet bins all have an influence on the storage potential of fruit and on optimum conditions for their storage. These handling operations must be evaluated as they relate to storage and quality maintenance.

Currently only a small portion of the orange crop is stored even briefly. There is no commercial storage of other subtropical fruits such as avocados, mangos, and Persian limes. Since there is some year-around demand for each of these fruits, it would be advantageous to store a part of each crop to extend the marketing season for fresh fruit. However, no satisfactory methods have yet been developed for storing these fruits for more than a few weeks.

Dried fruits and tree nuts are subject to insect infestation during storage, while they await processing, and during holding in marketing channels. Research is necessary to develop more effective pesticidal treatments.

OBJECTIVE: Determine optimum storage requirements for fruits as to temperature, humidity, air circulation and atmosphere composition to allow an extended marketing season, prevent temporary seasonal surpluses, and maintain quality. Develop improved storage practices to prevent insect infestation of dried fruit and tree nuts.

RESEARCH APPROACHES:

A. Determine optimum temperature and relative humidity conditions for extended storage of fresh fruit.

B. Determine tolerances of fruit to modified atmospheres (low oxygen, increased carbon dioxide, etc.) and what, if any, benefits can be attained.

C. Evaluate new or improved fumigants to prevent insect infestation in stored tree nuts and dried fruit.

D. Evaluate improved refrigeration practices and determine which chemical and thermotherapy treatments will best retard decay and other deterioration in storage.

E. Study the effect of reduced atmospheric pressure on fruit quality in storage.

F. Determine what values accrue from air scrubbing to remove ethylene and other volatiles from storage rooms.

G. Determine whether the market life of subtropical fruits can be extended by modifying present precooling and refrigeration practices.

H. Develop storage environments to maintain quality of Valencia oranges, Marsh and Red Blush grapefruit, Lulu and Booth 8 avocados, papayas, and pineapples during a 3- to 4-month period.

This research will be coordinated with RPA 403.

POTENTIAL BENEFITS: Improved procedures for storage of fruit and tree nuts will reduce waste and extend the season of availability--thus helping to stabilize marketing. Improved storage of fruit prior to processing will be valuable to allow higher quality processed products. High quality fruit will be available to consumers for a longer period and producers could receive increased returns.

RECOMMENDED RESEARCH EFFORT:

TF Recommendation
(Scientist Man-Years)

1972	1977
17	22

RPA 404-C Improved Transportation

SITUATION: The high degree of perishability of fruits requires either that they be quickly sold on local markets, processed locally shortly after harvest, placed in controlled temperature storage where feasible, or rapidly transported to their destination.

Several innovations have made it feasible to bring fresh fruits on a year-around basis to all parts of the nation and to bring tropical fresh fruits to all areas of the U.S. Mainland.

The first innovation is the increased use of aircraft for fruit transport. This is brought about by the use of air freighters and the potential use of "jumbo" jets to various population centers throughout the nation. Increased use of air transport for fruit will also require a new generation of various types of containers, packages, and handling procedures for maintenance of optimum quality.

The second innovation is the employment of refrigeration and controlled or modified atmosphere use in railroad and truck transportation both of

which have tended to extend product shelf-life at a high level of "freshness" for a considerable period of time.

The third innovation in transportation is containerization of the freight which has tended to reduce handling, and time required for transport. Containerization combined with previously mentioned innovations (air transport, controlled atmosphere, and refrigeration) should help bring fresh fruits to the consumer's table at any season and any place in the nation.

These processes, however, are still rather costly and will require considerable research before their optimally economic application can be achieved.

OBJECTIVE: Find avenues of lower cost operations of diverse technological innovations in the areas of transportation and storage of fruit in various sections of the country.

RESEARCH APPROACHES:

A. Evaluate efficiency of product handling at shipping, transfer, and receiving points through time and motion studies and other research devices.

B. Determine optimal efficiencies in the use of various temperature and atmospheric controlled transport systems. Determine what modifications may be needed in load size or pattern. (Special emphasis should be given to product quality maintenance in these uses.)

C. Determine an optimal transport-mix (i.e., alternative use of air, rail, boat, truck transportation in individual shipments) for various fruits through test shipment using alternative modes of shipping.

D. Test various kinds of containers for the maintenance of quality during air transport including handling, precooling and modivied atmosphere effects.

POTENTIAL BENEFITS:

Maintenance of high quality through efficient and effective transportation can bring fresh fruits of many types to consumers throughout the country, irrespective of season, at reasonable prices.

RECOMMENDED RESEARCH EFFORT:

TF Recommendation
(Scientist Man-Years)

1972	1977
13	18

RPA 404-D Postharvest Physiology

SITUATION: Major future developments and new technology relating to quality maintenance of fresh fruits will depend on an active basic research program. This will involve basic research on intracellular activities relating to maturation, ripening, and senescence of fruit tissues. It will involve basic studies on the nature of low-temperature injury and other physiological disorders. Applied research leading to improved quality maintenance for the ultimate consumer relies heavily on a continuing supply of basic knowledge.

Research is only beginning to reveal a few of the basic mechanisms governing ripening and senescence in fruits. Ethylene, a volatile produced by most fruit tissues, has long been recognized as exerting a marked effect on ripening and senescence. Recent research has shown some of the possible precursors of ethylene, and how it may be formed and exert its influence. The important role of modified atmospheres in retarding respiration and ripening is being investigated. Modified atmospheres are used commercially to retard deterioration of apples and to a limited extent for pears and sweet cherries. Recent experimental evidence indicates that peaches, plums, and some citrus fruits respond favorably to certain modified atmospheres, usually containing reduced concentrations of oxygen and increased concentrations of carbon dioxide. The effects of modified or controlled atmospheres on respiration and other vital processes in living fresh fruits are largely unknown. The effects of low-oxygen levels and other modified atmospheres on growth of microorganisms and on physiological disorders merit investigation.

OBJECTIVE: Obtain more knowledge of the vital processes of fruit tissues, such as respiration, ripening, and senescence, as they relate to quality and market life.

RESEARCH APPROACHES:

A. Study the biochemical reactions that occur in fruit tissues after harvest and determine what enzyme systems are affected.

B. Determine the effects of various atmospheres on respiration rates and find which atmospheres are most effective in

prolonging life of fruit tissues.

C. Study ethylene formation in fruit tissues and determine its relationship to senescence.

D. Determine the effects of environmental conditions on the physiology of fruits as related to quality attributes.

E. Evaluate chemicals that may retard ripening and senescence; determine their mode of action and how they influence quality.

POTENTIAL BENEFITS: Benefits would be confined largely to a better understanding of basic responses of fruit tissues to conditions imposed during handling, packaging, storage, transportation, and marketing. Results and "spin-off" from the basic research may lead to new technology aiding quality maintenance.

RECOMMENDED RESEARCH EFFORT:

TF Recommendation (Scientist Man-Years)	
1972	1977
8	11

RPA 404-E Identification and Control of Postharvest Diseases

SITUATION: Postharvest diseases are responsible for a high percentage of the $102 million annual loss that is estimated to occur during transit, unloading, and subsequent marketing of fruit. Additional losses due to disease occur while fruit is in storage in production areas and in terminal markets. In New York City, for example, approximately 700 carloads of fruit are lost annually be decay 5/. These losses can be reduced by improved handling or by treatments now available. Research is needed to develop improved control procedures and to develop controls for diseases for which no preventative treatments now exist. One report 5/ estimates that 30 percent of all fruit decay is caused by species of Penicillium. Other fungi causing serious losses of fruits are species of Botrytis, Rhizopus, Monilinia, Diplodia, Phomopsis, and Alternaria.

Fruits usually carry fungus spores and bacteria on their surfaces at harvest. Under certain temperature and moisture conditions these organisms may cause disease and resultant spoilage. Maintenance of proper

5/ U.S. Dept. Agr. Cir. 773

temperature and humidity conditions during marketing will slow aging and ripening and minimize decay by slowing the rate of development of decay organisms. Many fungi, however, even under optimum conditions for the fruit, can develop and cause decay during storage and marketing.

In addition to diseases caused by fungi and bacteria, there are many diseases which are not caused by pathogens but are due to physiological disturbances. Apple scald, pitting, and brown core are examples. Some are induced by slow cooling or delayed storage; others are brought on by temperatures that are too low for the fruit, yet not freezing.

A continuing need for identification of diseases both new and old exists. Older previously identified diseases may appear with different symptoms that are not easily recognized by inspectors, and people without training in pathology.

Further expansion of deciduous and subtropical fruit production is expected. As production increases, the fresh marketing season for a portion of the crop should be extended. If the storage season is extended, however, the related problems of wastage from decay and functional disorders may increase. Several postharvest fungicides of varying effectiveness have been developed for reducing decay during marketing. The need to develop both more effective chemical and non-chemical controls, such as heat treatments, for decays and physiological disorders is urgent.

OBJECTIVE: Identify various postharvest diseases of fruits and develop safe effective controls that will minimize waste and allow an extended marketing season.

RESEARCH APPROACHES:

A. Develop treatments or procedures to reduce postharvest decay without adding unacceptable chemical residues, including the evaluation of thermotherapy, refrigeration, and low-toxicity chemical treatments.

B. Identify diseases on domestic and imported fruit that cause important losses, particularly in terminal markets.

C. Study the physiology and biochemistry of decay-producing organisms.

D. Attempt to isolate and identify natural components of fruit having fungistatic properties.

E. Determine how biphenyl or derivatives can be used to provide decay reduction in export citrus fruit shipments and still meet the EEC residue tolerances.

This research will be coordinated with RPA 205.

POTENTIAL BENEFITS: Reduced wastage from diseases during marketing and more consistent quality of fruits for consumers.

RECOMMENDED RESEARCH EFFORT:

TF Recommendation
(Scientist Man-Years)

1972	1977
14	15

RPA 501 - OBJECTIVE EVALUATION OF FRUIT QUALITY (GRADES AND STANDARDS)

SITUATION: Increasing need exists for automated objective methods of evaluating quality to make possible rapid reliable grading and inspection of large quantities of fruit. Inspection and grading of fruit is done almost entirely by hand with decisions based on human judgment of appearance, color, and condition. It is highly desirable to replace or augment these judgments with instrument evaluation. New technology using reflectance and transmission spectroscopy, sonic vibrations, and physical measurements offer promise of materially improving the objectivity of grades and standards. Many current grades and standards are not as useful as they could be because they do not adequately measure the characteristics of interest to users. Effective grades and standards should assist buyers in obtaining product characteristics they desire and assist sellers in obtaining appropriate compensation for what they sell.

Evaluation of harvest maturity is a serious problem with many fruits. If fruit is harvested too soon, the quality is poor. If not harvested soon enough, losses in handling, transporting, and storing the over-mature fruit are high. More adequate methods of evaluating maturity and condition of fruit could both improve the quality for consumers and reduce losses in marketing.

As an example of the potential benefit from this type of program, objective methods for removing over-mature apples and apples with watercore, both of which have poor storage potential, could reduce storage and marketing losses by several million dollars. Moreover, possible benefits from premium prices for high quality apples, following sorting by light transmittance techniques into high, medium and low quality categories, might be ever larger.

OBJECTIVE: Develop instruments and objective methods to accurately grade or sort fruit for external and internal quality. This includes finding techniques of measurement that can be used to distinguish among the various levels of quality found in fruit products.

RESEARCH APPROACHES: The following techniques will be explored to determine which methods are suitable for rapid accurate evaluation of the desired quality factor:

A. Reflectance and transmittance of visible and infrared radiation, X-rays and Gamma rays, and sonic and ultrasonic vibrations.

B. Electrical conductivity and dielectric properties analysis, thermal properties analysis, and reaction to mechanical force.

Each of these techniques will be evaluated to determine the accuracy, reliability, speed, and cost of the new technique compared to that of the present method. In addition, the effect of the new technique on the quality of the final product will be determined. With some fruit crops, further work is needed to determine what chemical and physical characteristics constitute good quality. From these evaluations, methods having potential value at a reasonable cost will be developed, prototype instruments will be constructed and tested. Results of these developments will be made available to instrument manufacturers, food processors, and handlers, and to inspection and grading programs for their implementation.

This research will be coordinated with related work under RPA 304.

POTENTIAL BENEFITS: This research should improve the quality of fruit delivered to consumers and reduce marketing costs and losses. Development of new objective methods of measuring fruit quality will improve the standardization of quality evaluation (inspection) programs. Costs of buying and selling are greatly reduced when, because of grades and standards, a buyer does not need to personally inspect each lot which he purchases.

Example - Apples might be sorted into groups with a predicted storage life and those with high probability of breakdown could be sold first. Also, apple quality could be measured objectively and apples of high quality could be sorted and sold at premium prices. This monetary reward for quality should encourage producers to put more high quality fruit on the market.

RECOMMENDED RESEARCH EFFORT: The recommended research effort in scientist man-years shown below is higher than that proposed in the 1966 report titled "A National Program of Research for Agriculture." It proposed a 133 percent increase while the Fruit Task Force recommends a 350 percent increase by 1977. The reason being that the current effort is very small (4 SMY's) and new technologies offer great potential for developing advanced instrumentation. Also the Instrumentation Research Laboratory and the new Color Research Laboratory (USDA) are inadequately staffed and State Agricultural Experiment Stations have only a limited program in this research area.

TF Recommendation
(Scientist Man-Years)

1972	1977
12	18

RPA 503 - MARKETING EFFICIENCY

INTRODUCTION: Efficiency is an important aim of marketing. An efficient marketing system contributes to a greater output of goods and services from given resources. It can help reduce marketing margins. Increase returns to farmers and lower prices to consumers. The existence of uneconomic marketing organizations, overlapping and duplication in the assembly and distribution of products raises marketing costs. The importance of fruits and fruit products to our national health, the wide range in fruit marketing methods, the expansion of processing and packaging, and rising labor and other input costs call for increased efforts to improve efficiency of fruit marketing system and of the firms within them. Research aimed at eliminating existing inefficiencies in marketing can make important contributions to the general welfare.

RPA 503-A Economic and Physical Analyses of the Preparation, Processing, and Handling of Fruit Crops

SITUATION: Fruit production, primarily in response to population growth, has trended upward historically and the trend can be expected to continue for some time into the future. But increased output is only one of many developments that can be expected in the industry.

The major changes of the future will include shifts in consumers' tastes, income and location; new technology throughout the industry from production to retailing; and the development of new processes and products.

These developments will lead to shifting economic forces that result in pressure for continuous industry adjustment. Some of the manifestations will be, (1) shifts among commodities in relative importance, (2) shifts among production areas in relative importance (including foreign), (3) changes in size of industry firms, and (4) changes in forms and amounts consumed.

OBJECTIVE: Determine the most efficient methods, equipment, locations, and products for assemblying, packing, processing, distributing, and merchandizing commercial fruits.

RESEARCH APPROACHES:

A. Develop basic input-output data relative to location, process, products, and equipment.

B. Analyze and evaluate methods, locations, institutions, and products in view of developments and trends.

POTENTIAL BENEFITS: The information generated in this effort will facilitate internal industry adjustment and result in increased overall efficiency.

RECOMMENDED RESEARCH EFFORT:

TF Recommendation (Scientist Man-Years)	
1972	1977
14	15

RPA 503-B Marketing Firm and System Efficiency

SITUATION: Costs for moving and handling fruits from the field to the consumer accounts for an increasingly large part of total marketing costs. The physical distribution system, which includes transportation, materials handling, warehousing, inventory control, and packaging is receiving increased attention as a potential area for cost reduction in marketing fruits. Factors that have influenced this interest in physical distribution include:

1. Higher freight rates and reduction of available storage and transit privileges by carriers.

2. Increased storage, warehousing, and handling costs.

3. Broadening of product lines of canned, frozen, dried, dehydrated, and fresh fruits.

4. Outmoded handling facilities including facility locations determined by needs of the past, and;

5. Realization by managements of many firms that this is a potential area for sizeable cost reductions.

OBJECTIVE: Increase efficiency of marketing fruits by developing least-cost physical distribution systems to move fresh and processed fruits from points of production through various marketing stages to final markets.

RESEARCH APPROACHES:

A. Determine types, structure, and organization of present physical distribution systems utilized by both the fresh and processed fruit industries.

B. Determine through least-cost, linear analysis:

a. Where storage facilities should be located -- near the area of production, near the market, or somewhere in between.

b. How large and what kind of storage or warehouse facilities are needed.

c. How transportation facilities can be utilized to regulate product flow through processing and marketing.

d. The level of product supply to maintain in a market area.

e. Where cleaning, grading, packaging and labeling should be performed between the production areas and markets.

f. How consolidation and coordination of shipments could be achieved and resulting contribution to overall efficiency of the distribution system.

POTENTIAL BENEFITS: This research can lead to substantial cost reduction in transporting, handling, and warehousing fresh and processed fruits.

RECOMMENDED RESEARCH EFFORT:

TF Recommendation (Scientist Man-Years)	
1972	1977
12	14

RPA 503-C Economic Analysis of Market Organization and Structure for Fruit Crops

SITUATION: The marketing of fruit crops may occur on two major levels: (1) at the shipping point markets and (2) the terminal or central markets. At the shipping point markets which are located near the producing area, the fruit crops are assembled and then distributed to the central terminal markets. The basic structure of these markets is composed of wholesalers (merchants), and agents (brokers, auctions, etc.). Over time, however, both of these forms of middlemen have had to give way to integrated operations. In particular, many large retailers (e.g., supermarkets) are performing most of the wholesaling functions which were carried on in the terminal as well as in the shipping point markets. Moreover, there

is evidence that even the assembling is increasingly carried on by retailers through their own field buyers who contact producers directly. Vertical integration is therefore reducing the number of wholesalers located at shipping points and terminal and central markets. At the same time, it is involving retailers in increasingly diversified activities (e.g., buying, storage, transportation, financing, grading, etc.) at the wholesale level. This in turn reflects upon the efficiency and managerial capabilities of the retail outlet particularly in view of consumer insistence on additional "built-in services" (pre-packaging, a high degree of quality control, ready availability of various fresh fruits throughout the year rather than throughout the season). Efficient operation of newly evolving market structures will be subjected to very severe tests. This is particularly true because of continual increases in the price for fresh fruits which, at present, places the product out of the reach of a considerable sector of the American population.

OBJECTIVE: Define the factors which affect the operations of the marketing system for fruit crops and to evolve means of making the system more efficient.

RESEARCH APPROACHES:

A. Investigate alternative marketing systems and structures to determine the degree of efficiency in the distribution of fruit crops.

B. Contrast operations of various conventional functionaries such as wholesalers, brokers, etc., in the channels of distribution with integrated operations.

C. Evaluate the effect that marketing orders and marketing agreements, on both the State and Federal level, have on the institutional efficiency of the markets of various fruit crops. In this conjunction also, the work of various State marketing commissions will need to be included.

D. Develop models of fruit marketing systems which specifically aim at the reduction in marketing costs.

POTENTIAL BENEFITS: Stabilization or reduction in the cost of marketing, which is rising more rapidly than cost of production, will enable larger sectors of the economy to afford a greater selection of fruit crops than appears feasible at present. Increased availability of fruit to all population sectors of the economy will conduce to greater health and general well-being of the population.

RECOMMENDED RESEARCH EFFORT:

TF Recommendation
(Scientist Man-Years)

1972	1977
7	12

OTHER RESEARCH PROBLEM AREAS OF CONCERN TO THIS TASK FORCE

RPA 102 - Soil Structure, and Soil, Plant, Water, Nutrient Relationships

INTRODUCTION: The importance of research in this area and its potential application to fruit production strongly suggests careful consideration and coordination of research efforts among soil scientists, agricultural engineers, pomologists and others. The perennial nature of many of our principle fruits and the development of technology leading to mechanization of production, harvesting, and handling of them have placed increased emphasis on the need for basic research relating attributes of soil structure to fundamental soil, plant, water and nutrient relationships. With the advent of mechanized production, the importance of soil structure as it influences the establishment of plantings, their productive life and the nutrition and physiological functions relating to productivity and uniformity in plant development and fruit maturity, require increased attention.

SITUATION: Development of machines to replace human labor has emphasized the importance of soil structure as it relates to efficiency in machine performance and its effect on crop growth. The movement of heavy equipment through the fields and orchards in the many steps associated with production and harvesting has an obvious adverse influence on soil structure and the maintenance of optimum conditions for plant growth.

The critical importance of achieving high productivity and uniformity in growth and maturity of fruit plants for mechanical harvest places increased importance on the soil and its physical and biological properties which influence crop response. Because many fruits are well adapted to only limited climatic areas and soil types, it is important to learn more about the relationship between soil factors and plant responses and about methods of maintaining or even enhancing soil productivity. It is also appropriate to identify and develop methods of modifying existing features of soil structure that limit plant responses. In time we may be forced to use soils that are not now economically practical for fruit production.

OBJECTIVE: Determine the features of soil structure which directly or indirectly influence the establishment of fruit plantings, their productive life and uniformity in plant growth, productivity and fruit maturity.

RESEARCH APPROACHES:

A. Identify the attributes of soil structure which influence the establishment of productive orchards and uniformity in tree growth.

B. Develop soil management practices that will alleviate or minimize the adverse effects of agricultural equipment on soil structure and therefore on water penetration and movement, aeration, nutrient availability, and root growth.

C. Determine the factors in soil management that influence uniformity in fruit maturation and develop procedures for minimizing tree to tree and plant to plant variations.

D. Develop procedures for management of soils now unsuitable for fruit production that would permit their commercial use in the future.

E. Coordinate research with RPA 304-C.

POTENTIAL BENEFITS: Increased efficiency in fruit production derived from longer lived planting, improved yields and quality of fruit, and lower unit costs of production.

RECOMMENDED RESEARCH EFFORT:

TF Recommendation (Scientist Man-Years)	
1972	1977
15	20

RPA 105 - Conservation and Efficient Use of Water for Agriculture

INTRODUCTION: Substantial competition for existing water supplies among industries, cities, and other interests outside of agriculture is placing increased emphasis on the need for economy in water use by agriculture. Increased cost and declining availability of labor require development of economical, automatic systems that may conserve both labor and water.

SITUATION: The occurrence of unpredictable intermittent droughts, often for extended periods, places a widespread and simultaneously heavy demand on existing sources of water. Since it is recognized that an adequate supply of water available throughout the year is essential to quantity and quality fruit production, information is needed on the capacity of existing and future water sources and on methods for conserving water to be used for fruit production.

Adequate moisture is essential for the proper establishment of fruit plantings. If soil moisture becomes deficient either during fruit set

or maturation, the yield and quality of the crop can be seriously affected. The need for adequate quantities of "high quality" water for irrigation of fruit in arid areas is an established fact. Rising land and labor costs coupled with increased financial investment in equipment, fertilizer, and agricultural chemicals in the production of fruits in humid, relatively high rainfall areas will necessitate the use of more supplemental irrigation as an "insurance" factor in future production. It is doubtful that mechanized fruit production can be successfully established and maintained without dependable supplies of water for irrigation, hydro-cooling, and other uses. Thus all of the factors that relate to conservation and efficient use of water in crop production should be considered. Special attention must be given to the problems that may be peculiar to fruits in relation to the cultural practices followed and special requirements for high yields, quality, and uniformity in maturation of a perishable crop.

OBJECTIVE: Determine the special requirements of the fruit industry for water, particularly with respect to quantity and quality in humid production areas, and to develop efficient methods for insuring an adequate and continuous supply.

RESEARCH APPROACHES:

A. Develop improved procedures for determining frequency and quantity requirements for supplemental irrigation of fruit in humid production areas.

B. Identify and evaluate management practices and environmental factors that influence efficient use of water through all stages of fruit production.

C. Assess various techniques and materials that may be employed to reduce moisture loss from the soil and plant surfaces without detrimental effects on crop yields and quality.

D. Evaluate the practicality of using water derived from food processing plants, and other secondary sources for irrigation of fruits.

E. Determine the minimum water quality requirements for supplemental irrigation to specific fruit crops in different soil and climatic environments.

F. Coordinate research with RPA 304-C.

POTENTIAL BENEFITS: Increased efficiency in utilization of water to obtain maximum production of high quality fruit at the lowest unit cost.

RECOMMENDED RESEARCH EFFORT:

TF Recommendation (Scientist Man-Years)	
1972	1977
15	20

RPA 106 - Efficient Drainage and Irrigation Systems and Facilities

INTRODUCTION: Efficient drainage and irrigation systems and facilities have a direct bearing on biological efficiency, productivity and mechanization in fruit production. Although the need for and use of irrigation in the production of fruit in the arid regions of the United States need not be defended, improved systems that will reduce labor requirements and improve efficiency in water distribution, application, and drainage require further research.

SITUATION: Use of supplemental irrigation for fruits grown in humid areas of the United States is increasing. The advent of mechanical harvesting lends added emphasis to the importance of irrigation. Present investments in land, equipment, fertilizer, and agricultural chemicals provide an added incentive to employ supplemental irrigation and use efficient drainage systems for disposal of excess water and salinity control, to insure high yields and quality in fruits produced.

Intensive and specialized cultural practices employed in fruit production require the use of much larger quantities of fertilizer and pesticides than are normally used in the production of agronomic crops. As increasing national attention is given to eutrophication, pollution, and siltation of natural water resources, the special problems created by rainfall and irrigation practices on clean-cultivated fruit plantings deserve special attention. Methods and procedures of irrigation and drainage must be developed to minimize the movement of soil, pesticides, and fertilizer elements from resident sites. Pomologists should be consulted on the special problems of the fruit industry relating to research on drainage and irrigation systems and facilities. Close coordination of effort with RPA 105 is essential.

OBJECTIVE: Develop efficient drainage and irrigation systems and facilities to obtain high productivity in mechanized fruit production.

RESEARCH APPROACHES:

A. Develop improved irrigation equipment that will conserve both labor and water.

B. Develop cultural systems that will prevent surface run-off of water from cultivated fruit plantings and the associated movement of soil, nutrients, and pesticides into water courses.

C. Explore new and improved methods for determining irrigation water requirements.

D. Explore new concepts and ways of irrigating fruit crops in both arid and humid production areas with special emphasis on subterranean systems.

E. Develop efficient drainage systems applicable to lands used for fruit production.

POTENTIAL BENEFITS: Increased efficiency in utilization and disposal of water resulting in reduced fruit production costs and minimization of possible water pollution problems arising from fruit culture.

RECOMMENDED RESEARCH EFFORT:

TF Recommendation
(Scientist Man-Years)

1972	1977
5	10

RPA 314 - Bees and Other Pollinators of Fruit and Tree Nut Crops

Many of the fruit and tree nut crops are dependent upon honeybee or other insects for pollination. Basic information on their pollination requirement is scant or based on varieties no longer in production. Research is needed on degree and kind of insect pollination required to produce the maximum crop for each variety of fruit and tree nut now in commercial production, particularly on newer varieties adapted for mechanical harvesting. Information is needed on the amount of supplementary insect pollination with honeybees that is required under various environmental conditions and the most efficient methods of utilizing better colonies and strains of honeybees adapted for pollination of specific crops. Since

the number of honeybee colonies in the U.S. has declined at the rate of one percent per year during the past 20 years and the honeybee is the only insect pollinator that can be moved into an area when desired, increased emphasis should be given to full evaluation of honeybees and other insects as pollinators of fruit and tree nut crops. At present there is practically no State or Federal research devoted directly to pollination studies of either fruit or tree nuts. The Task Force strongly recommends that such insect pollination research be initiated and expanded to 10 scientist man-years by 1972 and increased to 15 scientist man-years by 1977.

RPA 506 - Supply, Demand, and Price Analysis

SITUATION: Henry Ford once said that you can have your car in any color you want as long as it is black. Many farmers not too long ago felt that whatever they produced should be readily acceptable to the public in terms of both quality and quantity.

Increasingly, however, the wishes of the public are considered. In accord with wishes, tastes, and desires as expressed by consumers, large food retailers which buy direct from producers engage in specification buying and in contractual relationships with producers.

While demand analysis concerned itself mainly with the product disappearance derived from historical (trend) occurrences, the newer approaches include analyses of consumer behavior, development of product profiles, and the determination of the competitive position the specific product holds among other products of similar use in the market (i.e., the main competitor of a given fruit or fruit product may not be other fruits alone but other foods. Similar considerations hold for complementarity). In short, inclusion of consumer behavior and product profile analysis tend to give a much better picture of the demand than was previously feasible.

Similarly, the role that price plays in the demand for fruit needs to be further explored particularly since rapid transport can make fresh produce available to all sections of the nation throughout the seasons of production. In particular, measurements of price elasticities for fruits, will need to be undertaken under these newly arising conditions. Also the effect that changing incomes will have upon the demand structure for fruits will have to be further investigated.

The study of demand and price naturally leads to studies in produce availability. More specifically, future studies will be required to determine the extent to which various price levels will maintain the required flow of supplies of various fruits and fruit products at high quality standards and at the same time meet operating and income requirements of suppliers adequately.

OBJECTIVE: The first goal of research endeavor in the area of demand, supply, and price is to afford the consumer the correct product at correct quantities at acceptable (as low as possible) prices at the time and place the consumer requires the product.

The product qualitative aspects which are now gaining prominence will require further insights into consumer behavior and consumer attitude towards various fruits and fruit products so that increased consumer satisfactions may be obtained.

RESEARCH APPROACHES:

A. Fruit demand studies will need to include, aside from the usual demand analysis, in depth studies of consumer attitudes toward the product and studies of behavioral phenomena which guide consumer demands.

B. Pricing studies will now need to include the effect that increasing availability of "out of season" fruit may have on various regions of the country (e.g., determination of additional values that consumers place on counter seasonal availability of fruit). Also measurements will be required of the effect that increased product inflow from foreign countries (made feasible by adoption of new production and transport technology) will have on the price of domestic fruits and fruit products.

C. Further studies of producer response to price changes, studies of the increased impact of specification buying on the part of large food retailers and vertical integration in fruit distribution will also have to be undertaken. Such studies would require simulated production systems coupled with conditions of vertical integration and models of conceivably complete industrialization of fruit production.

POTENTIAL BENEFITS: The study of supply, demand, and price condition should afford us a much better predictive capability than was heretofore possible. Anticipation of what consumers require, qualitatively as well as quantitatively will lead to a more satisfactory product in the hand of the consumer and more effective supply and price relationships.

RECOMMENDED RESEARCH EFFORT:

TF Recommendation
(Scientist Man-Years)

1972	1977
9	12

RPA 507 - Competitive Interrelationships in Agriculture

SITUATION: Fruit marketing is being characterized by increased integration, both vertical and horizontal. Processors are increasing their trend toward more contract buying, and can be expected to play a more active role in production to insure that fruit is produced to their specifications. Technological changes in transportation and communications are increasing the interdependencies of the markets. The market is becoming more national in scope, as better communication enables buyers and shippers alike to obtain instantaneous intelligence on price and supply in all terminal and shipping point markets. This has affected the traditional means of price determination; it is now difficult to determine where and how price is determined.

Competitive interrelationships among commodities are changing, primarily as a result of technological advances in production and marketing. As a result, commodities which are most adaptable to innovation will become more competitive, while other less adaptable commodities will tend to become luxury items, or in some cases disappear from the market. Synthetic substitutes will continue to make inroads into the market for natural fruit products, especially if prices of the natural products tend to get too far out of line.

Population growth and shifts, coupled with new transportation technologies will affect the location of production. Some production areas may decline in importance while others become more competitive as a result of these factors.

OBJECTIVE: (1) Estimate the impact of vertical and horizontal integration on the competitive market relationships, and identify and measure changes in these relationships; (2) Determine the relative competitive positions of the major producing regions and commodities, identify and evaluate factors responsible for changes in the competitive relationships; (3) Determine the nature of the price setting mechanism for fresh fruit; and (4) Evaluate the impact of demographic shifts and technological innovations on the location of fruit production.

RESEARCH APPROACHES: To adequately focus on the problems of competitive interrelationships in the fruit industry, it will be necessary to look at the industry in its entirety. Therefore, a first step to be undertaken is the development of a simulation model of the industry. This model will then become the primary tool for analyzing specific objectives.

POTENTIAL BENEFITS: Research of this type will provide both industry leaders and government policy makers with basic information on the direction in which the industry is moving and thus serve as a foundation

on which to base decisions. It will also provide a means for evaluating the economic impact of actual and potential changes in the industry.

RECOMMENDED RESEARCH EFFORT:

TF Recommendation
(Scientist Man-Years)

1972	1977
7	8

RPA 508 - Development of Domestic Markets for Farm Produce

SITUATION: While the overall demand for food products including fruit crops may be quite inelastic (i.e., the human stomach can absorb only a limited amount of food), there exists among various food products some rather keen competition. Thus, whole milk competes with filled milk, beef with pork, lamb, etc. Similarly, keen competition exists among the various fruit crops. A given variety of apples may compete against another and apples in general can compete with pears or oranges. Given the limited physical capacities to consume foods and a certain budget restraint, each consumer must make a choice of items he wishes to select for his own use. It is within that framework that individual industries may differentiate and improve the demand for their individual product. Thus, the apple industry, or even more narrowly the Washington apple producers, for example, can improve the demand for their product by strict quality control (from the tree to table), by suitable promotion, and advertising and by maintaining a continued two-way flow of information from the industry to the consumer and from the consumer to the industry. The first such flow would be to instruct the consumer of the availability, the wholesomeness, the taste, the health value, etc., of the product. The counter-flow, being of equal importance, determines the wishes of the public in terms of shape, color, packaging, taste, and structural consistency of the product.

It is in these areas that research is particularly required.

OBJECTIVE: Determine optimal returns to advertising and promotional expenditures in market developmental activities on the part of industry members. Devise ways and means for the attainment of information regarding the requirements and wishes of consumers with respect to fresh fruit and food products.

RESEARCH APPROACHES:

A. Measurement of the effect which various forms of promotion and advertising have on the demand for various fruit crops. This spectrum may range from in-store promotion to newspaper (omnibus ads) advertising to radio and TV campaigns. Once these results are obtained, a proper mix of market developmental activity must be computed and designed in order to obtain the highest possible results for funds expended on such activities.

B. Determination of consumer requirements and wishes with respect to individual products should be carried out directly in conjunction with market developmental activities. Thus, for example, the knowledge of a specific color, of say oranges, found to be most attractive to the average consumer can be very helpful in raising the demand for the product.

POTENTIAL BENEFITS: Improvement in the efficiency of bringing information about a product to potential consumers; higher rates of consumption; improved and efficient means of obtaining information flow from consumer to producer; and availability of products more nearly aligned with the demand and specification of the consumer.

RECOMMENDED RESEARCH EFFORT: Task Force recommendation not developed.

RPA 510 - Farmer Bargaining Power

INTRODUCTION: The heightened interest of growers in gaining more bargaining power stems largely from dissatisfaction with their present price and income levels. The emphasis on mass distribution and market orientation to better satisfy consumer wants may require growers to become better organized if they are to meet the needs of the market. Fruit growers along with other producers seek to improve their income position relative to other segments of the economy. While much has been written on farmers lack of bargaining power, too little research has been done to guide producers in improving their position or to give direction to public policy in this area.

SITUATION: Conditions existing beyond the orchard greatly influence growers' net income. Retailers and processors are becoming fewer and larger. Processing is expanding in relation to fresh fruit marketing. A larger number of processors are contracting in advance for their raw products and growing a portion of their supply requirements. These changes, coupled with increasing costs and the ability of growers to oversupply

the market have accentuated the marketing and purchasing problems of many individual fruit growers and small cooperatives.

Growers seek guidance in finding ways to deal effectively with large-scale processors and retailers. They need a better understanding of how to use the tools available to them - cooperative marketing and processing, collective bargaining, pooling, market agreements and orders, market information and quality standards.

OBJECTIVE: Help fruit growers strengthen their marketing and bargaining position in dealing with buyers and handlers.

RESEARCH APPROACHES:

A. Evaluate the role of grower organizations and government programs in improving farmers' bargaining and marketing position.

B. Appraise the adequacy of present State and Federal legislation and regulations in providing an adequate framework for group action by growers.

C. Analyze alternative techniques used to facilitate group action, including cooperatives, unincorporated associations, and contracts.

D. Study ways various groups, including cooperatives, can improve fruit growers market position through integration, merger, consolidation, and leasing.

E. Evaluate the effectiveness of marketing agreements and orders in improving fruit growers' income and the potential of using the allotment authority to balance production and demand.

POTENTIAL BENEFITS: Strengthening fruit growers' market position through group action could give them a greater voice in pricing their products and establishing terms of trade. Through organization growers may be able to make better use of government programs to improve quality and match supply with demand.

RECOMMENDED RESEARCH EFFORT: The Marketing and Competition Task Force recommended the scientist man-years for RPA 510. The amount to be used on research to improve bargaining power for fruit growers would be a part of that overall program effort.

RPA 511 - Improvement in Agricultural Statistics

SITUATION: Social and technological changes have produced a virtual revolution in American agriculture during the past two decades. A slowing down of this process appears unlikely. Instead, there are many indications that it will continue and even accelerate in the future. One of the few things that has remained virtually unchanged during this period has been the collection of agricultural statistics. The only means that we have of measuring change has remained basically unchanged.

There are four types of agricultural statistics, specifically relating to fruits, in general use today. These types of information are: (a) Census data collected by the Census Bureau; (b) production statistics collected by the Statistical Reporting Service, USDA; (c) market news data collected by the various commodity market news branches in the Consumer and Marketing Service, USDA; and (d) retail prices collected by the Bureau of Labor Statistics. Each of these agencies are independent and unrelated to one another and there is no coordination in the scope or method of collecting statistics. In addition, each of these agencies collects data for specific purposes, none of which are related to research needs.

Two of the agencies mentioned are in the U.S. Department of Agriculture and would, therefore, be subject to specific consideration by this Task Force. The data collected by the Consumer and Marketing Service have a direct business orientation with little or no consideration of data modifications needed in research. This is only slightly less true of the information collected by the Statistical Reporting Service. In both cases information is supplied on a voluntary basis; there is no basis for specifying the composition of the reporting population, and therefore little basis for judging how well the reporting population represents the universe.

Space is insufficient for a comprehensive examination of agricultural statistics, but we might cite one specific example of the need for improvement. Statistical Reporting Service reports total quantity and a season average price for specific products. Nothing relating to the characteristics of the product is published. We do not know the price-quantity relationships, changes within a season, or how product characteristics change from season to season. Likewise, market news reports prices by product characteristics but does not report the quantity of product with specific characteristics. Also, market news data reported at the wholesale level are unrelated to market news data at shipping point, and both of these are unrelated to Statistical Reporting Service statistics at the farm level.

OBJECTIVE: Obtain improved agricultural statistics needed for information, research, and provide a better basis for business and public policy decisions.

RESEARCH APPROACHES:

A. Determine the specific types and amounts of information desired by surveying business firms, public officials, researchers, and other users of agricultural statistics.

B. Compare information obtained in A above with the types and amounts of information collected at the present time. From this comparison, differences between existing and desired information would be specified. Examine these information differences in the framework of cost-benefit analysis to determine "feasible" information "needs."

C. Make pilot studies of the feasible item to provide a real-world test of the costs and benefits involved. If the results of a specific pilot study showed that benefits-costs ratio exceeded a prespecified level, the item would be reported on a continuing basis. But, if this pilot study showed that the item failed this test, it would be dropped.

POTENTIAL BENEFITS: Businessmen and public officials need an ever increasing amount of information for the purpose of making business and public policy decisions. Improved data will provide a better means of measuring the many forces working to change agriculture. Likewise, better information for business and government will provide a better basis from which to plan for the future.

RECOMMENDED RESEARCH EFFORT: A substantial input will be needed to improve the current statistics for all commodities including fruit.

RPA 601 - Expansion of Foreign Markets for U.S. Farm Products

SITUATION: Fruit and fruit products comprised approximately five percent of U.S. agricultural exports in 1967. Fresh fruit accounted for 52 percent of all fruit exports. Citrus fruits were the major fruit exports, accounting for more than 50 percent of all fresh fruit exports and approximately 30 percent of total fresh and processed fruit exports. Citrus fruit juices were an additional 10 percent of all fruit exports.

Most of our fruit exports are sent to European and South American countries which have relatively high standards of living. These countries are also

rapidly increasing their production of fruit. Therefore, research is needed to increase the consumption of fruit in less well developed countries, and to find ways of treating or processing U.S. fruits so that they can be delivered to these countries at prices that will increase demand.

Producing deciduous and citrus fruits for competition in world trade calls for a wide range of research on production, harvesting, processing, and marketing costs (including packaging and transportation) as well as additional research to develop new varieties of fruits to satisfy consumer preferences in foreign markets.

Dehydrated fruit products such as pear and apricot purees, foam-mat dried fruit juices and fruit juice tablets offer special opportunities because of reduced volume and weight, low shipping costs and reasonable stability without refrigeration. Low shipping costs over long distances to foreign markets make this approach particularly favorable. Marketing research needs to be done with regard to the introduction of these products.

To expand foreign utilization of fruits and fruit products, more efficient, effective, and especially economical packaging, transportation, and storage must be found; also, new and effective antioxidants, color dyes, anti-mycotics, and other preservatives which meet both domestic and foreign standards of health and safety must be developed.

OBJECTIVE: Increase foreign consumption of United States fruit products through development of economic and efficient packaging, transportation, and storage techniques, and discover new and safe food preservatives and additives meeting foreign import standards.

RESEARCH APPROACHES:

A. Develop new and more economical ways to dehydrate fruit to optimum moisture level for greatest stability.

B. Design and test moisture impervious materials for packaging low moisture products.

C. Identify and develop acceptable chemical preservatives to protect dried fruit products from moisture and oxidative deterioration.

D. Devise better and lower cost freezing processes.

E. Design improved refrigeration and containers for frozen fruit products for transport vehicles -- truck, boat and plane, and test in actual market channels.

F. Establish effective and safe additives such as color dyes, antioxidants and antimycotics acceptable under foreign import standards.

G. Determine which types of products are best accepted in major foreign markets.

H. Determine economic effects on foreign trade in fruits from adoption of different levels and combinations of the improved systems developed above.

POTENTIAL BENEFITS: Expansion of markets by making products available in areas not currently served and thereby stabilize price for fruit. Improve balance of foreign trade.

RECOMMENDED RESEARCH EFFORT:

TF Recommendation
(Scientist Man-Years)

1972	1977
12	16

RPA 702 - Protect Food Supplies from Harmful Microorganisms, Naturally Occurring Toxins, and other Toxic Ingredients

SITUATION: High acid foods such as fruit require minimum heat treatment to insure freedom from infectious microorganisms and their toxins. Color and flavor are often adversely affected even by this comparatively mild treatment. Frozen fruit products do not undergo sufficient thermal processing to kill bacterial spores. Efficient in-plant sanitation is necessary to prevent product contamination. Good quality control measures are required to assure that dried fruit products are free of harmful bacteria, yeast, and mold contamination. The tendency to market higher moisture dried fruit has placed added responsibilities on growers and processors to monitor microbial contamination at every processing step, plus providing adequate packaging and acceptable chemical bacteriostats for the final product. No satisfactory preservatives are available for low acid fruits such as dates and figs.

OBJECTIVE: Develop and improve techniques for processing fruit products free from harmful microorganisms, toxins, and other contaminants.

RESEARCH APPROACHES:

A. Develop new methods and techniques for prevention, reduction, and elimination of microbial and toxic contaminants (e.g., UV irradiation in liquid with photo sensitizer to insure more efficient germicidal action at lower irradiation energy).

B. Develop more effective antimycotics and antibacterials.

C. Isolate and identify harmful toxins.

D. Develop by-products which could be used as preservatives and which are biodegradable and detoxified by enzymes in fruits.

E. Survey industry practices and provide latest information on sanitation and preservation.

POTENTIAL BENEFITS: Certainty of the freedom of fruit products from harmful microorganisms and toxins will be enhanced, especially for those products which are not thermally processed. A wider market for fruits blended with other foods will be assured due to better compatibility from a microbial standpoint. Methods for identification and elimination of toxins will reduce greatly this source of contamination. Useful byproducts will be generated which will aid in the preservation of fruit products.

RECOMMENDED RESEARCH EFFORT:

TF Recommendation
(Scientist Man-Years)

1972	1977
7	10

RPA 901 - Alleviate Soil, Water, and Air Pollution

SITUATION: Wastes from fruit processing plants and orchard management are becoming an increasingly serious problem as urban expansion brings residences closer to growing areas and processing plants.

Waste materials develop during the processing of fruit in such steps as washing fruit or equipment, trimming, peeling, pitting, fluming, and the like. Liberal use of water is necessary to maintain adequate sanitation of plant and product. Pollution problems created by current methods of disposal from the expanding fruit processing industry could influence

public welfare and expansion of the industry. Also, needs for pure water for agricultural, industrial, and domestic use are increasing so that previously used methods for fruit waste disposal are no longer satisfactory. Increasingly local, State, and Federal regulatory agencies are pressing the food processing industry to abate water and air pollution and new control methods are essential to continued operation of food processing plants.

Over 16 billion pounds of citrus fruit is used per year and over 14 million pounds of waste organic matter develops, exclusive of about 1.3 billion pounds converted to dried citrus pulp and molasses. In a few cases the effluent from citrus processing plants is handled in municipal sewers but the volume and character of the waste usually makes this impractical and the waste is handled in a variety of ways depending upon location, type, and size of plant. Certain disposal procedures give rise to unpleasant odors and create water pollution problems. Complaints are increasing as residential areas build up around processing plants. The volume of citrus fruit processed is expected to increase markedly based on new plantings so problems will become extremely critical. Particulate matter from feed mill drier stack gases also contribute to problems in air pollution.

Processed deciduous fruit totals about 10 billion pounds per year and produces wastes estimated to contain over 10 million pounds of organic matter per year.

OBJECTIVE: Develop technology to reduce the quantity of waste arising from fruit processing and orchard management and adjust the pollution of effluents to levels compatible with Federal control regulations at reasonable costs.

RESEARCH APPROACHES:

A. Develop new processing methods and, plant cleanup procedures to reduce the waste effluents and increase their concentration so they can be more efficiently processed.

B. Develop new and improved methods of treating wastes such as concentrating by reverse osmosis, by more intense methods of aeration, by chemical treatment, and by improved microbiological procedures.

C. Develop methods of purifying brine solutions so they can be reused.

D. Develop methods of controlling emission of particulate matter from stack gases of feed mills and dryers used for processing wastes.

E. Develop recovery methods for valuable materials from selected plant effluents such as distilled oil from certain citrus wastes.

F. Develop improved methods of orchard management to reduce wastes and improve methods of treating these wastes.

G. Evaluate economic cost and effectiveness of alternate pollution control methods or systems and determine the effects of their adoption on representative firms and on the fruit industry.

POTENTIAL BENEFITS: Abatement of air and water pollution would contribute to the welfare of the public and permit efficient fruit production and processing.

RECOMMENDED RESEARCH EFFORT:

TF Recommendation
(Scientist Man-Years)

1972	1977
16	22